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Hawaii Agricultural Experiment Station

Report

1940

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Variations occurring between strains of Guinea grass

HAWAII AGRICULTURAL EXPERIMENT STATION

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

1940

by

J. H. BEAUMONT, *Director*

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Table of Contents

Page

Introduction 5

Agronomy 9

Animal Husbandry 18

Chemistry and Soils 32

Entomology 38

Horticulture 46

Nutrition 58

Parasitology 63

Plant Pathology 67

Plant Physiology 75

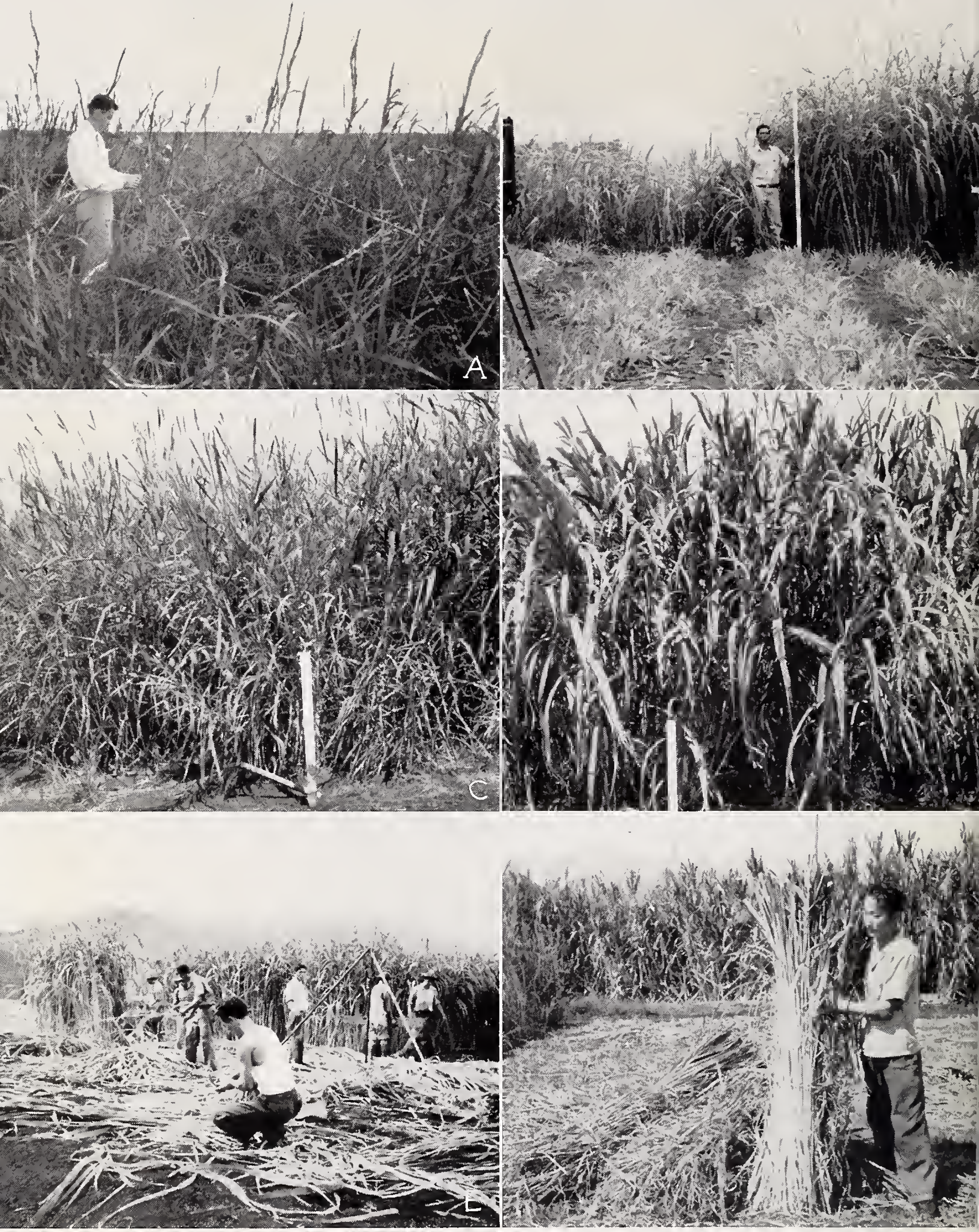
Poultry Husbandry 82

Soil Physics 86

Branch Stations 89

Publications 92

Fiscal Statement 94



Frontispiece.—Diseased Napier grass and disease-resistant strains developed at this station: A, Standard Napier which has completely collapsed due to disease; B, left, standard Napier and right, a robust Napier-Merker hybrid which is resistant; C, fine-stemmed, resistant Merker grass with rather hard, unpalatable stems; D, hybrid Napier-Merker strain which is resistant but has broad leaf and soft stems; E, station workers preparing resistant planting material for free distribution to ranchers and dairymen; and F, bundles of planting material ready to be shipped to growers.

Introduction

The Hawaii Agricultural Experiment Station is the agricultural research division of the University of Hawaii. Its function is to develop the agricultural resources and opportunities of the Territory.

The research activities of the station are conducted in the laboratories and on the farm at the University, at the three branch stations on Oahu, Maui, and Hawaii, and in cooperation with plantations, ranchers, and farmers at strategic points throughout the Territory. Thus the station is able to study agricultural problems and to solve them both in the laboratory and in the field. Indeed, much of the research of the station and consequently its direct value would be impossible without the cooperation and financial support of numerous individuals and corporations.

Striking examples of cooperative effort which have yielded results of great value are the beef-cattle feeding trials (fig. 2). During the past 6 years it has been conclusively demonstrated that, under reasonably good range conditions, the feeding of supplementary molasses is advantageous. Molasses has been found to have a value of $8 to $12 per ton in terms of increased beef produced. Whether or not the results of these tests conducted at Kapapala ranch, Waianae company, and Waialua agricultural company are solely responsible, it nevertheless has been found, in a recent survey, that the feeding of molasses to beef cattle has trebled from 1,228 tons in 1938 to 3,628 tons in 1940.

The value of these experiments is not alone in the fact that a local byproduct can be fed profitably, thus reducing the dependence of local animal industries on mainland feeds. The findings are being extended further. For example, another plantation byproduct, the trash brought to the mill in grab-harvesting, after passing through the washer, may be fed to dairy and beef cattle with molasses supplement. Cooperative experiments are now in progress to determine the value of these materials in dry-lot feeding. If they are successful, it is quite possible that beef and dairy production in the Territory may be considerably increased, at a profit to plantations, cattlemen and dairymen, and the general public alike.

The macadamia nut brings to mind other cooperative experiments from which growers and the Territory will benefit. One hundred or more acres of land, owned by various cooperators, have been planted

Figure 1.—New laboratory facilities of the nutrition division.

to the 80 varieties selected from among 60,000 or more bearing seedling trees. After 4 to 8 years it should be possible to select from among these 80 varieties the ones that are best adapted, highest yielding, and of best quality.

The Oahu sugar company has for a number of years furnished land and water to the station for cultural, breeding, and variety tests of vegetable crops and for disease- and insect-control investigations. These are but a few of the numerous instances of how the facilities of the station have been augmented to undertake investigations which otherwise would not be possible and which are continuously yielding dividends to the Territory.

The station itself is at present so limited in personnel, land, and funds that many types of field experiments, which require accurate controls and constant supervision, are not possible. It is hoped that additional land and greater support can be given to the station for these important investigations.

Interest continues to develop in food and feed crops which could be produced on a subsistence or emergency basis. While the greater proportion of the efforts of the station have been and still are directed toward developing diversified crops still the subsistence and local market crops have not been neglected. The station is in a better position than ever before to render valuable aid should an emergency program be forced upon the Territory. Varieties, seasonal and climatic adaptability, irrigation and cultural requirements of lettuce, peppers, carrots, beans, beets, and many other of the smaller crops have been surveyed.

The frontispiece of this report illustrates a contribution of the station which cannot, perhaps, be measured in dollars but which nevertheless may contribute to the well-being of every person in the Territory. Napier grass is our most important forage crop as well as a valuable pasture and range grass. The station in 1934 undertook to develop higher yielding, more palatable, and more nutritious strains of this grass. After close observation, testing, and rigid selection, a number of new strains were ready for distribution when in 1939 an eye-spot disease, new to the Territory, appeared and destroyed large fields of standard Napier grass. Many of the new strains were attacked but others were found to be highly resistant when standard Napier right next to them was practically killed out. Ranchers, and especially dairymen, were facing an emergency, and the station and Extension Service immediately arranged to put large quantities of planting material of the resistant strains into their hands.

Disease resistance is uncertain, however, for it is known that disease organisms often change or mutate and are then able to attack strains of the host plant that formerly were resistant. The bean-rust organism is an example. Apparently during the past year a new strain has developed here or has been introduced, for varieties of beans formerly resistant are now found to be susceptible. Thus varieties of beans resistant to the new rust organism must be found or developed. It is hoped that another form of the Napier disease will not appear. The station, realizing the importance of this plant, has attempted to prepare for any contingency by requesting permission of the Board of Commissioners of Agriculture and Forestry to introduce resistant strains of Napier from Florida, where eye-spot disease has been prevalent for many years and where various types of the disease may have

Figure 2.—Cooperative experiments with ranches are essential to work in animal husbandry. Below is picture of Kapapala ranch cowboys segregating steers for pen-feeding experiment.

developed. The request was not granted, even though the experiment station of the Hawaiian Sugar Planters' Association had agreed to quarantine the cuttings in a manner which would fully safeguard the agricultural interests of the Territory.

The 1939 Legislature appropriated funds for additions to the agricultural building at the University, which were completed in June 1940. The laboratories in the new wing are being equipped and put to full use (fig. 1). These laboratories and facilities are a real asset to the research of the station, but additional facilities are urgently needed for the parasitology, agronomy, horticulture, nutrition, and poultry departments. This need will become critical should the land and buildings made available to the station by the United States Department of Agriculture be withdrawn. It is hoped that the Legislature may find it possible to provide such additional facilities.

The director is gratified that no major changes in staff have interrupted the research program of the station. Separations from the staff during the year included H. Kubota and J. Holzman, assistants in horticulture, and J. B. Bartlett, junior chemist. The leave of absence granted to J. E. Welch, assistant olericulturist, expired. The appointment of H. D. Michener as a research fellow also expired, and W. B. Storey is returning from study leave to take over his duties as assistant horticulturist.

During the year, Professor L. E. Weaver, of the Cornell university extension service, served as poultry husbandman, on an exchange arrangement with Professor C. M. Bice.

Of great benefit to horticultural research was the appointment of D. T. Fleming, of Lahaina, Maui, as collaborator. Mr. Fleming has long been giving freely of his time and knowledge to advance the station's research in the fields of fruit and nut crops. His appointment as a collaborator is, nevertheless, gratifying to this station.

Dr. S. S. Ballard, assistant professor of physics, accepted an appointment as collaborator in the field of soil chemistry.

Other additions to the staff included E. M. Hodges, assistant agronomist, Lily Utsumi and Warren Ikeda, assistants in horticulture, Russell Rosendahl, research fellow[1], B. Cooil, assistant in plant physiology, M. Matsuura, assistant in plant pathology, and Edward Inn, assistant in soil physics.

[1] Resigned June 30, 1940.

Agronomy

Classification of Pasture Lands

Diversified agriculture in Hawaii is confined to lands not reserved for cultivation of sugarcane or pineapples. On such lands occur the extremes of rainfall, topography, and soil. As a step toward evaluating the agricultural potentialities of these residual lands, chief among which are ranch pastures, a classification of the climatic zones of the Territory has been completed. This classification was based upon rainfall, elevation, and plant associations.

A tabulation of pasture species in the Territory, made in connection with the classification survey, lists 60 trees and shrubs, 116 grasses and sedges, and 131 herbs and miscellaneous species. These pasture plants are segregated according to the climatic zones in which they occur. It is now possible to recommend range species and management practices for ranches extending through several to all of the environmental zones. *(Ripperton, Hosaka)*

Introduction of Pasture Species

During the year, 66 species and strains of forage plants were introduced from many parts of the world and planted at one or more branch stations. The value of testing species over a wide environmental range was demonstrated. Temperate-zone grasses and clovers which did not grow at Haleakala (2,200 feet elevation) were vigorous and well adapted at Olinda (4,000 feet). Except at high elevations, material from the tropics seems best suited to Hawaiian conditions.

Rapid testing of new introductions prevents the grass gardens' becoming mere collections of exotic plants. Periodic notes are made on each species for not over 2 years; unless a grass merits pasture trial, it is discarded.

Cooperative trials have been established with ranchers and dairymen to test the more desirable species under practical conditions. *(Lyman, Ripperton)*

Evaluating Pasture Species

The value of a species for pasture purposes is dependent on a number of characteristics. The ideal species should establish itself quickly, persist well against other species, recover quickly after grazing, and produce a high yield of forage with a high proportion of leaf to stem. Finally, it should be palatable to stock. In order to measure these qualities, 20 grasses and legumes were planted at the University farm, each in a twentieth-acre plot, and periodically grazed. Observational data were taken on rate of recovery, relative yield, and leafiness of the forage, order of preference, and the part of the plant eaten.

The following table summarizes the characteristics of each species. *(Lyman)*

Table 1.—Evaluation of 20 pasture species[1]

Species	Time to establish	Recovery after grazing	Persistence	Yield	Leafiness	Palatability
Grasses						
Andropogon nodosum	3	3	5	3	3	3
Chloris gayana	5	5	5	4	3	3
Cymbopogon citratus	3	3	4	3	1	4
Cynodon dactylon	5	4	5	3	3	4
plectostachyum	5	5	5	4	3	4
Digitaria pentzii	1	3	3	2	5	5
Hyparrhenia rufa	3	3	2	3	3	3
Panicum antidotale	4	4	2	2	1	3
maximum	5	3	5	5	4	4
obtusum	2	4	4	2	3	3
prolutum	4	5	4	2	1	2
Paspalum urvillei	3	2	3	2	4	2
Pennisetum ciliare	3	4	4	3	3	3
clandestinum	3	3	5	3	3	4
setosum	4	4	4	4	2	2
Themeda gigantea	3	3	5	5	4	2
Legumes						
Desmanthus virgatus (immature)	3	4	5	3	3	5
Leucaena glauca (immature)	3	3	2	3	3	5
Phaseolus lathyroides	3	1	1	3	4	4

[1] 5, excellent; 3, average; 1, poor.

Persistence of Grasses and Legumes

In an extensive group of grass paddocks at Haleakala, the persistence of grass species in various mixtures has been tested under actual grazing conditions. In general, the common creeping grasses tended to displace other, more nutritious species.

In paddocks where kikuyu *(Pennisetum clandestinum)* was the basic grass, other species were rapidly choked out; after three grazings, solid stands of kikuyu resulted. Of the remaining species, panicum grass persisted well—the original stand in rows remained, but the dense kikuyu sod underneath kept the panicum stems from rooting. Under continuous grazing the latter would probably disappear. Woolly finger grass spread rapidly at first. It was dense in patches but will probably be gradually displaced. Rhodes grass was still prominent, but its vigor was greatly diminished. Three tropical legumes, *Indigofera endecaphylla, Desmodium tortuosum,* and *Stylosanthes guyanensis,* persisted in small quantities. The natural dominants of this region, Bermuda and rattail grass *(Sporobolus capensis)*, did not make headway against the kikuyu.

The paddock with woolly finger grass *(Digitaria pentzii)* as the basic species has given the best mixture and the greatest carrying capacity of the entire experiment. This species spreads principally while the soil is still loose, and once established it persists. When other grasses have filled in the interspaces and the soil has become compact, the woolly finger grass spreads slowly. Woolly finger grass and paspalum *(P. dilatatum)* made outstandingly better summer forage than Bermuda grass or kikuyu, remaining green throughout the dry summer just past.

Bermuda grass *(Cynodon dactylon)*, one of the dominant pasture species in the Haleakala region, did not spread as rapidly in its paddock as kikuyu, but it was gradually displacing less aggressive species. Rattail, the other dominant grass of the region, was volunteering throughout this paddock increasingly as the soil became more compact.

Temperate species of grasses and clovers failed to persist, even without competition from other grasses. Reseeding and fertilizing have failed to stimulate their growth. During the past winter, white clover *(Trifolium repens)* and red clover *(Trifolium pratense)* developed strongly in a reseeded, fertilized section of the Bermuda paddock but were killed out during the dry summer. *(Ripperton, Murphy, Hosaka)*

Clovers

Management. Cooperative trials with ranchers have shown that distribution of clovers at high elevations can be extended through seeding and proper management. Most pasture clovers are temperate species and, in Hawaii, seldom extend below elevations of 3,000 feet.

White clover *(Trifolium repens)* and hop clover *(Trifolium procumbens)* are found principally in upland areas of fairly continuous moisture, while black medic *(Medicago lupulina)*, bur clover *(M. hispida)*, and yellow sweet clover *(Melilotus indica)* ripen seed only in more seasonal climates. The best stands of white clover are found where the herbage is closely grazed but the pasture is periodically rested. On the other hand the relatively tall or trailing vetches, black medic, and bur clovers thrive when the grasses are allowed to grow tall, especially during the spring months.

Fertilization. A limited number of tests of soils from pastures containing white clovers gave a range in pH values from 5.5 to 6.8. Available phosphoric acid ranged from a trace to 400 pounds per acre, and available calcium oxide, from 1,400 to 9,000 pounds per acre.

Pot tests were initiated at Pensacola branch station to determine the effect of sunlight on the growth of Spanish clover *(Desmodium uncinatum)*, white clover, and black medic. Reduction of sunlight by approximately half reduced the growth of all three clovers, and particularly that of white clover.

Spanish and white clovers were planted in fertilizer pot tests in a residual red loam soil, as mixtures with Hilo grass *(Paspalum conjugatum)* and Bermuda grass. Spanish clover was stimulated strongly by lime and to a lesser degree by superphosphate, while the reverse was true of white clover. Rock phosphate increased the growth of Spanish but not of white clover. After several cuttings Spanish clover continued to produce undiminished as summer approached, but white clover decreased to a low level.

Rapid chemical tests 4 months after application of the fertilizers showed that the soils receiving rock phosphate had 500 pounds per acre of available phosphorus, while those receiving superphosphate had 150 pounds, and the soils receiving no phosphate, only a trace. The available calcium in soil treated with rock phosphate was 3,000 pounds as compared with 1,500 pounds in the check. Limestone had raised the pH from an initial value of 5.5 to 6.3, but rock phosphate had little effect.

In another series of pot tests the early stimulation of white clover by superphosphate was equally pronounced. After about 3 months, however, the check plants were nearly equal in growth.

In field tests installed at the Haleakala branch station on Maui (2,200 feet altitude) the clovers were planted with and without companion or nurse crops and with cross strips of the fertilizer treatments. Preliminary results closely follow those of the pot tests.

If superphosphate gives a strong initial stimulus to white clover in the field tests, application of this fertilizer at the time of seeding may be feasible. It should be stressed, however, that climate has a most important effect on clover growth, and the persistence of the crop will depend primarily on environmental conditions. *(Ripperton, Lyman)*

Napier Grass

Fungus Disease. For the first time in Hawaii a fungus disease, *Helminthosporium sacchari* (see p. 69), has infected Napier grass *(Pennisetum purpureum)*. A survey of the crop has shown that the disease appeared almost simultaneously on all islands, from sea level to the maximum height at which Napier grass is grown (around 2,700 feet). Some fields have shown only slight infection; in others the grass is nearly dead. It is as yet too early to determine the extent to which this disease will menace the crop in Hawaii, but experience elsewhere would indicate that the problem may become serious.

Strain Selection. The station is making every effort to secure disease-resistant strains of Napier grass for local ranchers and dairymen who depend upon this crop for livestock feed. Resistant stools from badly infected fields are being selected, and a search is being made for resistant material in other parts of the tropics. Judging from local evidence as well as reports from elsewhere, Merker grass, another strain of *Pennisetum purpureum,* is less susceptible than the standard Napier.

Selected crosses of Napier and Merker grass have, since 1934, been compared with standard strains of Napier to determine their value as soiling crops and for pasturage. Certain of these strains mature more quickly than Napier and recover more quickly after grazing. The selections are now being tested for resistance to the *Helminthosporium* fungus (see frontispiece).

The Napier-Merker crosses also produce seed which germinate well. This may be an advantage in planting gulches and other nonarable land. Among the vegetative parts, stool divisions appear to be more desirable planting material than the various types of stem cuttings, giving a surer stand and quicker initial growth. The cost of preparing stool divisions is greater, however.

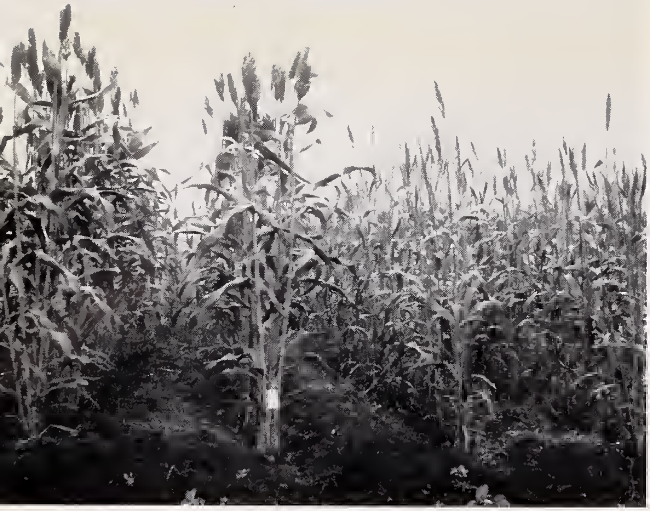


Figure 3.—Response of sorghum varieties to Hawaiian conditions: Left, well adapted Kansas Orange Sorgo; right, Black Amber Sorgo, less suited to climatic conditions at Poamoho farm.

Management. To determine the most effective pasture management of Napier, two systems of grazing were compared. In one field the grass was mature, the growth consisting of shoots from old stems and of new stems developing from the crown. In the other field the grass was not mature, and after grazing all ungrazed stems were mowed. Results, after two grazings, indicate that the mature Napier recovers more rapidly, gives a higher yield, and has a greater carrying capacity. Good gains in weight of livestock and high carrying capacity resulted when the fields were fertilized and grazed in rotation and the animals received supplemental molasses.

On most soils the yield and the percentage content of protein are greatly increased when nitrogen is applied to Napier grass between crops. An experiment is in progress to determine rate of absorption of nitrogen as well as phosphorus and potash by the plant. *(Takahashi, Ripperton, Murphy)*

Sudan Grass

Sudan grass *(Sorghum vulgare sudanense)*, once an important forage species in the Territory, is no longer cultivated widely because of its short duration and susceptibility to disease. The palatability, nutritive value, and high initial yield, however, encourage a search for improved types. Selected Sudan grass types and Sudan and forage-sorghum hybrids have been introduced from mainland stations and are being propagated, with some disease-resistant and vigorous types showing promise. Their value for local conditions will be determined by further observation and testing. *(Hodges, Lyman)*

Guinea Grass

Adaptability to a wide range of conditions and marked resistance to drought make Guinea grass *(Panicum maximum)* an important forage species. Yields are good under favorable moisture and fertility conditions, and the plant so far has been disease-free in Hawaii.

That variation exists within the species has been thoroughly established, a number of distinct types being known here and elsewhere (see cover). Several of these are being grown for observation under varying soil and climatic conditions, and some have been included in a grazing trial. A block of 500 seedling plants has been established at Poamoho farm for individual hill selection. *(Hodges, Lyman)*

Sorghums

Considerable interest has developed in sorghums as a possible source of grain for poultry and swine in the Territory, and a number of small plantings have been made. During the year the station procured for trial 36 varieties and strains of sorghums, representing true grain sorghums, forage types, and combination types. A number of these represent new strains which have recently been developed by mainland stations. Because of ravages by birds in the test plots, exact yields of grain could not be obtained. Seed developed normally, however, and a number of strains were outstanding (see fig. 3). An important feature of sorghum production in Hawaii is the free ratooning, to produce as many as three crops in a year's time. In temperate zones only one crop is obtained. *(Hodges)*

Starch Content of Taro

The yield of paiai or poi from a given weight of taro corms fluctuates considerably, due in part to the quantity of diseased tissue removed in the factory, but also to variations in the percentage of starch in normal corms.

In order to determine the value of the specific gravity method of measuring starch content, taro corms of varying size of the Moana variety were selected from an 8-month-old planting. After removal of the outer fibrous skin, the specific gravity and starch content were determined. Statistical analysis gave a highly significant linear regression coefficient of percentage of starch on specific gravity. This method should be useful for determining the yield of poi to be expected from taro corms. *(Takahashi, Ripperton)*

Sweet Corn

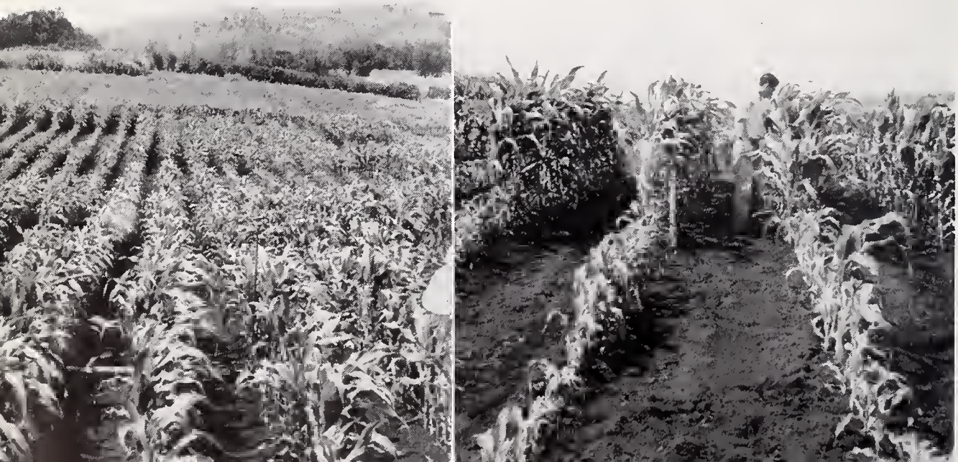
Selection. Since the introduction of U.S.D.A. 34 sweet corn from Puerto Rico in 1935, production of the crop in the Territory has increased appreciably. This variety, which is resistant to mosaic, can be grown the year round throughout low elevations where moderate moisture conditions prevail, although growth from November to February is retarded by low temperatures and short days.

The lack of seed-producing facilities and the extreme variability and toughness of pericarp have prevented widespread planting of this variety. During the past year all breeding material at the station, including open-pollinated and self-pollinated U.S.D.A. 34 lines and crosses with mainland varieties, was tested for tenderness of pericarp. Ear selections varied in their resistance to pericarp puncture, particularly among certain inbred lines. The future development of adapted types with more tender pericarp appears possible.

Mass-selected U.S.D.A. 34 sweet corn was planted at Haleakala to provide material for selection of types suited to higher altitudes.

Fertilization. The sweet-corn fertilizer experiment described in last year's report has been concluded. This test was designed to measure the order of response to the three main fertilizer components and their various combinations. The average yield of marketable ears at Haleakala, roughly 6,000 ears per acre, was less than half the yield obtained at Poamoho. This low yield at Haleakala was probably due to a combination of unfavorable climate and soil conditions. Nitrogen gave a marked increase in yield (significant at the 1 percent point) at Haleakala, and phosphorus and potash small yield increases which were not statistically significant.

Figure 4.—Left, general view of corn fertilizer experiment at Poamoho farm; right, marked contrast in growth between plot in foreground, receiving no fertilizer, and plot in background, given 100 pounds per acre each of nitrogen, phosphorus, and potash.



Yields of all plots were high at Poamoho. Early growth showed very striking differences between phosphorous plots and no-phosphorous plots, but these were reduced as the season advanced. The number of marketable ears per acre at Poamoho was greatly increased by the application of phosphate (significant at the 1 percent point). Nitrogen and potash produced yield increases which were smaller but proved to be significant upon analysis of the data. The soil at Poamoho is representative of many areas in the Territory where sweet corn is a potential crop. Recommendation of fertilizer formulas based on a single test must be only tentative, but for conditions similar to those at Poamoho farm, a medium-nitrogen, high-phosphorous, and low-potash fertilizer would seem to be applicable. *(Hodges, Takahashi)*

Animal Husbandry

Pasture Fattening

During the year a third cooperative trial was completed at Waianae company, to determine the value of cane molasses as a supplement for Aberdeen Angus steers on pastures of koa haole *(Leucaena glauca)*. Results of the three trials are briefly summarized herein.

The first trial, with 30 steers on 60 acres, lasted for 246 days; the second, with 24 steers on the same area, for 444 days; and the third, with 30 steers, for 368 days.

Gains during each period were roughly proportional to rainfall. Precipitation was satisfactory during the first trial but not during the last two; drought was particularly acute in the third experiment. Average daily gains of 613-pound steers on koa-haole pastures, without cane molasses, were 1.15 pounds, 0.84 pound, and 0.44 pound for the three trials in order, or 0.81 pound for the three combined.

The steers fed supplementary cane molasses (ad lib.) consumed 4.97 pounds per day, on the average. They made average daily gains of 1.50 pounds, 1.05 pounds, and 0.75 pound in the three experiments, or a combined average of 1.11 pounds. Thus supplementary cane molasses increased daily gains per steer by 0.30 pound or 37 percent for the three experiments.

The supplement was especially valuable in preventing losses in live weight during the drought periods. Molasses feeding also improved the carcass grade and increased the marbling of the meat. For more detailed data on the experiment, see station Bulletin 85, *Beef Cattle Feeding Trials in Hawaii. (Henke, Work)*

Pen Fattening of Beef Cattle

The natural fattening ranges of some ranches in Hawaii are inadequate although the land is capable of carrying large numbers of breeder cattle. On the other hand certain byproducts produced at sugarcane and pineapple mills have fattening value for cattle.

A cooperative experiment with Kapapala ranch, completed during the year, was designed to determine the possibilities of feeding maximum quantities of cane bagasse and cane molasses as well as to establish the weight at which pen-fattened cattle should be marketed for maximum returns.

Sixty Hereford yearling steers, averaging 564 pounds in weight, were divided into six equal lots. In pens 1 and 2, 15 pounds of freshly cut green cane tops were fed per day plus unlimited quantities of a mixture of bagasse, molasses, and soybean-oil-cake meal in the proportion of 40 : 41 : 19. In pens 3 and 4 the same concentrate mixture was fed but cane tops were limited to determine the effect of reduced roughage intake. In pens 5 and 6 at least 15 pounds of cane tops per day were fed plus a mixture of molasses and soybean-oil meal in the proportion of 4 to 1. Steers from pens 1, 3, and 5 were marketed after 151 days on test, and those from pens 2, 4, and 6, at the end of 243 days. Gains, feed consumption, dressing percentages, and cost of gains are shown in table 2.

Table 2.—Gains, feed consumption, and feed costs in Kapapala pen-feeding trial

Pen	1	2	3	4	5	6
Days on test	151	243	151	243	151	243
Average daily feed consumption:						
Cane tops (pounds)	15.0	15.0	9.7	7.9	15.1	15.5
Bagasse do	7.1	8.0	7.0	8.4	....	....
Molasses do	7.2	8.2	7.1	8.6	10.7	12.7
Soybean-oil meal do	3.4	3.8	3.3	4.0	2.7	3.2
Bone meal do	0.03	0.08	0.02	0.09	0.02	0.10
Salt do	0.07	0.05	0.03	0.07	0.03	0.05
Average daily gain do	1.47	1.31	1.32	1.37	1.42	1.38
Total feed cost per pound of gain[1] (cents)	9.27	11.59	9.57	10.62	8.09	9.58
Average dressing percentage	51.6	55.1	52.2	55.6	51.9	55.3
Average price received per pound dressed weight (cents)	15.83	16.64	15.68	16.73	16.17	16.55
Average price received per carcass (dollars)	64.27	81.19	62.90	83.32	65.33	83.94

[1] Estimated prices per ton used in figuring feed costs: Cane tops, $2.50 (labor of cutting); bagasse, $2.50 (fuel value); molasses, $4.00; soybean-oil meal, $55.00; bone meal, $50.00; and salt, $15.00.

The molasses and soybean-oil-meal mixture, fed to the limit of appetite, plus 15 pounds of green cane tops, was as efficient in producing gains as the more expensive mixture containing 40 percent cane bagasse.

Over the shorter feeding period, limiting the cane tops resulted in lower gains. When pen feeding was continued for 8 months, however, reduced cane-top consumption was accompanied by increased consumption of concentrates, and better and more economical gains. Marketing the cattle after 5 months resulted in lower dressing percentages for all lots, as well as lower prices for carcass beef.

The heavy rate of molasses feeding (up to 12.7 pounds per head daily) did not seem to have a deleterious effect upon the animals. Histological studies of animals consuming this quantity over an 8-month period showed no undue kidney damage.

This experiment suggests that pen feeding may be feasible where range fattening areas are unsatisfactory, and particularly in times of drought. *(Henke, Work)*

Roughages for Dairy Cattle

Rhodes Grass Versus Sudan Grass. Four double-reversal experiments have now been completed, comparing green Rhodes with green Sudan grass as a roughage for dairy cows. Each experiment consisted of three 4-week periods.

Milk production (4-percent-fat-corrected) was 3.4 percent higher, on the average, when Sudan grass was fed. This difference, while small, was statistically significant. In only one of the four trials was milk production slightly higher when Rhodes grass was fed. Details of the tests are shown in table 3.

Superiority of Sudan over Rhodes grass was greatest in experiments 2 and 4, conducted during periods of the year when "rust" was least prevalent on Sudan grass. It is possible that the rust may have adversely affected the feeding value of this grass.

Rhodes grass was markedly less palatable than Sudan grass, as shown by the amounts consumed. Average consumption of Sudan grass was 35.6 percent greater for the four trials, and this higher roughage consumption was doubtless a major factor in the higher milk production.

Table 3.—Milk production of dairy cattle on Rhodes grass and on Sudan grass

Experiment	Number of cows	Date of experiment	Daily feed consumption		Average weight of cows	Average butterfat in milk	Average daily milk production (4%-fat-corrected)
			Grass	Concentrates			
			Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*
Sudan							
1	6	1/6/38-3/30/38	59.3	22.1	1,107	3.50	37.2
2	8	6/30/38-9/21/38	55.5	15.7	1,068	3.79	26.4
3	6	11/24/38-2/22/39	49.9	20.0	1,124	3.40	36.1
4	8	3/2/39-5/24/39	54.5	13.5	1,138	3.44	29.3
Average	*7*		*54.8*	*17.8*	*1,109*	*3.53*	*32.2*
Rhodes							
1	6	1/6/38-3/30/38	37.3	22.1	1,107	3.50	37.6
2	8	6/30/38-9/21/38	36.0	15.7	1,052	3.81	24.7
3	6	11/24/38-2/22/39	41.0	20.0	1,125	3.39	35.4
4	8	3/2/39-5/24/39	47.3	13.1	1,123	3.45	26.9
Average	*7*		*40.4*	*17.7*	*1,102*	*3.54*	*31.1*

Samples of the roughages were taken daily and later analyzed. Average analyses of 216 samples of each grass are shown in table 4.

Calculations of actual intake per cow of dry matter, crude protein, and total nutrients from roughage show that, while nutrient intake was larger when Sudan grass was fed, the difference was not so great as the difference in green weight of roughages consumed, since Rhodes grass is higher in dry matter.

Whole Napier Versus Cut Napier Grass. Three 12-week trials, each with 8 cows, have been conducted to determine milk production on *whole* Napier grass as contrasted to milk production on *cut* Napier grass. When whole Napier grass is fed, cattle tend to eat only the

Table 4.—Average analyses of Sudan grass and Rhodes grass

Grass	Dry matter in green feed	Calculation on a water-free basis—				
		Crude protein	Ether extract	Nitrogen-free extract	Ash	Crude fiber
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Sudan	21.69	8.77	1.75	41.63	36.24	11.48
Rhodes	25.27	6.94	1.49	42.31	38.36	10.91

leaves, and the less palatable stems are wasted. When the grass has been passed through an ensilage cutter, however, little waste of forage results.

In trial 3, completed during the past year, milk production was 6 percent higher when whole Napier grass was fed; in trial 2, increased production was only 3.2 percent; and in the first trial, production was about the same on the two types of roughage. Consumption of roughage was determined by weighing the portions supplied, then weighing and deducting unconsumed residue. Roughage consumption (chiefly of leaves) was much higher in each trial when whole Napier was fed, with an average increase for the three trials of 53 percent. The weigh-back from the whole Napier was almost entirely the coarse stems. The economics of feeding cut and whole Napier should have further investigation. The value of increased milk production when whole Napier is fed should be considered in relation to the quantity of forage produced per acre, the cost of harvesting, and the cost of cutting with ensilage cutter. The problem should also be investigated in relation to the agronomic question of short cycle cutting.

Guinea Grass Versus Napier Grass. One 12-week double-reversal experiment with 8 cows has been conducted, comparing green Guinea grass and green Napier grass as roughages for dairy cows. Both roughages were cut in an ensilage cutter, and samples were taken daily for moisture determinations and chemical analyses.

The difference in milk production on these feeds was small and not statistically significant. Consumption was practically the same, indicating approximately equal palatability. Analyses show similar composition, but Guinea grass, being higher in dry matter, supplies more nutrients when equal quantities of the green forage are consumed.

Mexican Grass Versus Napier Grass. One 12-week trial was conducted comparing green Mexican grass and green Napier grass as dairy roughages. Both grasses were run through an ensilage cutter, and samples were taken daily for chemical analyses. The experiment began with six cows but Mexican grass proved so palatable and the supply was so limited that it was necessary to reduce the number of cows to four.

Milk production was higher when Mexican grass was fed, but the number of cows on test was too small for final conclusions. The cows consumed 53 pounds of Napier grass daily as compared to 108 pounds of Mexican grass.

The Mexican grass was relatively low in dry matter and crude fiber, which facts probably account for its palatability. However, growth habits and yields (at University farm) do not justify extensive use of this grass as a soiling crop, since materially more labor is required to produce a ton of Mexican grass than of Napier grass.

Desmanthus virgatus Versus Napier Grass. One 12-week double-reversal experiment was conducted comparing green *Desmanthus virgatus* and green Napier grass as dairy roughages. Because of the limited supply of *Desmanthus virgatus*, the test comprised only four cows. Both roughages were cut in an ensilage cutter prior to feeding, and samples were taken daily for analyses.

Milk production was 4.8 percent higher when *Desmanthus virgatus* was fed, but since only 4 cows were on test, definite conclusions are not justified. Consumption of this leguminous roughage was low, but the protein content is double that of Napier grass on a water-free basis. Since green *Desmanthus virgatus* is higher in dry matter than Napier grass, the difference in protein content on the green basis is even greater. *(Henke, Maruyama)*

Concentrate Feeds in Dairy Rations

Cottonseed Versus Soybean-Oil-Cake Meal. A second double-reversal trial was completed during the year comparing cottonseed meal and soybean-oil-cake meal as protein supplements in dairy rations. The rations consisted of 25 percent pineapple bran, 25 percent cane molasses, 15 percent linseed-oil-cake meal, 3 percent coconut-oil-cake meal, 1 percent each of salt and steamed bone meal, and 30 percent of either cottonseed- or soybean-oil-cake meal. Napier grass was fed as roughage. Each trial included 8 cows and continued for three 4-week periods. Results are given in table 5.

Table 5.—Milk production of dairy cows on soybean- and cottonseed-oil-cake meals

Experiment	Average daily roughage consumption	Average daily concentrate consumption	Average live weight of cows	Average butterfat in milk	Average daily milk production (4%-fat-corrected)
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*
Soybean-oil-cake meal					
1	36.4	12.4	1,069	3.84	24.0
2	52.4	17.0	1,144	3.57	31.2
Average	*44.4*	*14.7*	*1,106*	*3.70*	*27.6*
Cottonseed-oil-cake meal					
1	36.0	12.4	1,066	3.97	23.2
2	53.5	17.0	1,138	3.63	31.0
Average	*44.7*	*14.7*	*1,102*	*3.80*	*27.1*

Milk production was slightly lower and butterfat content slightly higher in both trials when cottonseed-oil-cake meal was fed. Cottonseed-oil-cake meal is not generally available in Honolulu but can be secured on special order, frequently at a lower ton cost than soybean-oil-cake meal.

Table 6.—Composition and estimated digestibility of rations low and high in fat

Ration	Low-fat	High-fat
	Percent	*Percent*
Composition:		
Cane molasses	25.0	25.0
Pineapple bran	38.0	35.5
Soybean-oil-cake meal	25.0	27.5
Coconut-oil-cake meal	10.0	7.0
Copra	....	3.0
Salt	1.0	1.0
Steamed bone meal	1.0	1.0
	100.0	100.0
Digestibility:		
Total crude protein (by analysis)	17.9	19.1
Digestible crude protein (estimated)	10.9	11.4
Total nutrients (by analysis)	94.2	95.4
Digestible nutrients (estimated)	66.6	69.3
Total fat (by analysis)	2.8	4.4
Digestible fat (estimated)	2.6	4.3

Value of Fat. Rations which include large amounts of cane molasses and pineapple bran are likely to be low in fat. The effect of adding fat to such rations was measured in a 12-week double-reversal experiment with 6 cows. Details of the rations fed are given in table 6 (preceding page).

Green Napier grass was fed as roughage to both lots of cows. Since the high-fat ration was slightly higher in both digestible protein and total nutrients, 3.84 percent less of this ration was fed than of the low-fat ration, to equalize the intakes of these elements. Results of this trial are summarized in table 7.

Table 7.—Milk production and butterfat percentages of dairy cows on high- and low-fat rations

Ration	Average daily feed consumption		Average live weight	Average butter-fat in milk	Average daily milk production	
	Roughages	Concentrates			Actual	4%-fat corrected
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
High-fat	61.3	16.0	1,108	3.78	28.2	27.2
Low-fat	65.6	16.7	1,107	3.59	27.6	25.9

Actual milk production was only 2.2 percent higher when the high-fat ration was fed but because of a higher fat content in the milk, milk production on a 4-percent-fat-corrected basis was 5.0 percent higher. This increase was statistically significant. The experiment is being repeated.

Cane Molasses Yeast. In a 12-week double-reversal experiment with 7 cows, dried yeast made from cane molasses was substituted for oil-cake meals in a ration fed to dairy cows. The control ration included 25 percent soybean- and 10 percent coconut-oil-cake meals. In the experimental ration, the molasses yeast was substituted for these protein supplements. In addition, both rations included 25 percent cane molasses, 38 percent pineapple bran, and 1 percent each of salt and steamed bone meal. Green Napier grass was fed as roughage. Results are shown in table 8.

Milk production (4%-fat-corrected) was 13.9 percent higher when the control ration was fed; this difference was statistically significant. The yeast ration was less palatable, and some difficulty was experienced in getting the cows to eat their full allotments. It is possible that the yeast would be eaten more readily if it replaced part

Table 8.—Milk production on yeast made from cane molasses

Ration	Average daily roughage consumption	Average daily concentrate consumption	Average live weight of cows	Average butterfat in milk	Average daily milk production (4%-fat-corrected)
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*
35% molasses yeast....	67.5	18.6	1,063	3.58	20.2
25% soybean- and 10% coconut-oil-cake meals	62.2	19.0	1,059	3.48	23.3

rather than all of the oil-cake meals in the ration. Roughage consumption was 8.3 percent greater when the yeast ration was fed.

Analyses show that the control ration contained 2.56 percent fat and the yeast ration, only 0.78 percent fat. It is possible that lack of fat was a factor in the lower milk yields when the yeast ration was fed. A second trial with molasses yeast, in which the quantity of fat supplied in each ration has been equalized, is now in progress. *(Henke, Work, Maruyama)*

Concentrate Feeds for Growing Heifers

Cane Molasses Yeast. Cane molasses yeast has also been tested as a protein supplement for growing dairy heifers. A liquid form of the yeast, containing 83 percent moisture and 7 percent protein (N × 6.25), was fed at intake levels up to 12 pounds per head daily, in an equal quantity of cane molasses. Acceptable growth was obtained when this yeast formed the greatest single source of protein.

A dried form of the yeast (40 to 42 percent total protein) was also fed to growing dairy heifers, both as a partial and as a complete substitute for the protein supplied in the check ration by soybean-oil-cake meal and fish meal. Growth on the yeast-containing ration was equal to and in some cases better than on the check ration.

Urea as a Protein Substitute. Dairy heifers that, from 6 months of age, have received most of their required protein from urea (4 percent urea in the concentrate ration) have freshened normally, with normal calves (see fig. 5). As lactating heifers they are being fed a concentrate ration which contains 3 percent urea, with 15.3 percent total protein and protein equivalent. So far milk production has been satisfactory and no off flavors have been detected in the milk, but the test has not continued long enough for final conclusions.

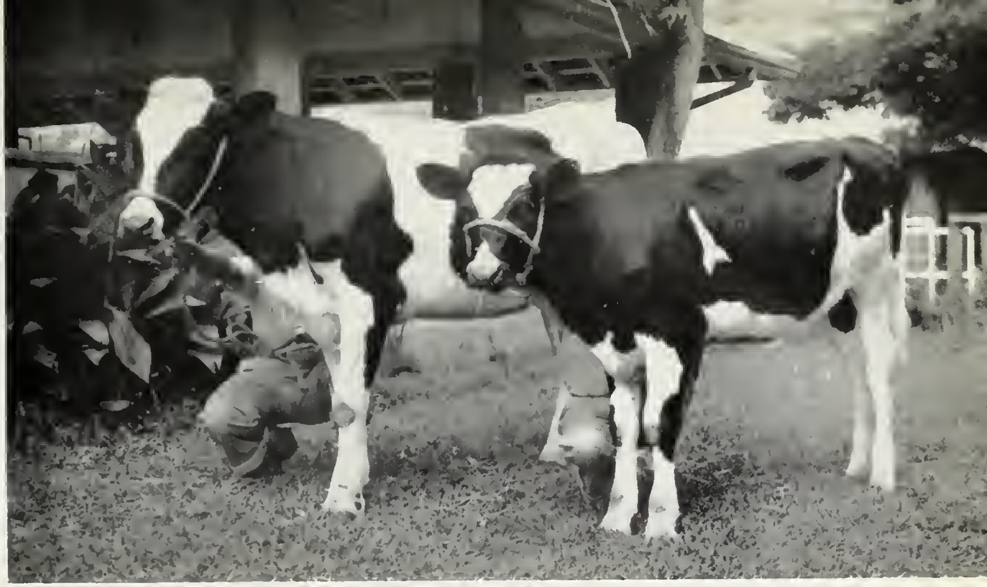


Figure 5.—Three-year-old Holstein cow, fed urea continuously from 6 months of age, and her 9-month-old daughter, also urea-fed from the age of 7 months.

Other heifers are being fed urea at the rates of 1.5 and 3 percent of the concentrate ration in the reversal plan of feeding. To date no significant changes in rate of growth due to urea feeding have been noted, but this trial also has not been concluded. *(Work, Henke)*

Digestibility of Hawaiian Feeds

The composition, digestibility coefficients, and digestible nutrients of three common Hawaiian forages (see cover and fig. 6) are presented in table 9.

The values on *Desmanthus virgatus* are in addition to those reported in 1938. The stems of this material were green and, although seemingly quite woody, were readily eaten by grazing animals. The Guinea grass was relatively mature (in seed) when harvested. The molasses grass was old growth obtained from a cultivated field, which, due to poor seed germination, had been allowed to grow and spread by its runners for a period of about a year.

Figures for molasses grass and *Desmanthus virgatus* represent the averages of two consecutive 10-day collection periods, which checked quite closely. With Guinea grass, the results are for only one 10-day collection period. *(Work)*

Feeds for Swine

Cane Molasses Yeast as Protein. The value of cane molasses yeast as a protein supplement for swine has been studied in a controlled paired-feeding experiment. The yeast replaced soybean-oil meal and local tuna-fish meal combined, at the rates of 25, 50, 75, and

Table 9.—Analyses, digestion coefficients, and digestible nutrients of three Hawaiian feeds

Feed	Number of steers	Length of collection period	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber	Total ash	Total nutrients
		Days	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Guinea grass (medium to old growth):	8	10							
Composition			26.17	1.46	11.88	0.38	8.85	3.60	
Digestion coefficients				34.00	49.00	6.00	41 00		
Digestible nutrients				.50	5.82	.02	3.63		10.00
Molasses grass (old growth):	4	20							
Composition			44.78	1.65	20.09	.87	19.02	3.15	
Digestion coefficients				38.00	62.00	51.00	66.00		
Digestible nutrients				.63	12.46	.44	12.55		26.64
Desmanthus virgatus (entire plant including semi-woody green stems):	4	20							
Composition			44.22	5.24	15.93	.91	19.62	2.51	
Digestion coefficients				61.00	70.00	57.00	43.00		
Digestible nutrients				3.20	11.15	.52	8.44		23.96

100 percent. Food intakes were equal for the experimental and check pigs of each pair.

The animal fed 100 percent yeast protein made gains equal to those of the check. At the 75-percent level of substitution, the check pig made faster gains early in the experiment. The yeast-fed pig picked up rapidly, however, and at the end of the test was only 4 pounds lighter.

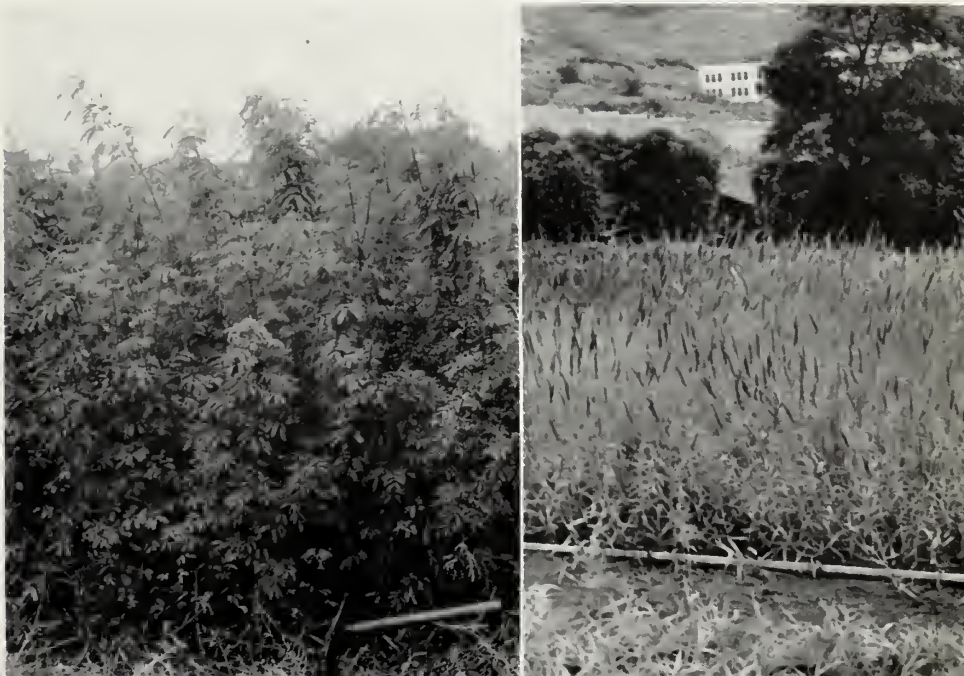
At the 50-percent level, the two pigs made the same gains. At the 25-percent level, the yeast-fed pig did materially better throughout.

These tests indicate that cane molasses yeast is a satisfactory protein supplement for swine.

The behavior of the pigs at the 25- and 75-percent levels of substitution suggested that a nutritional deficiency might have existed when the check ration was fed. This problem has since been studied more closely, and it has been found that 1 to 2 ounces of yeast per pig per day caused recovery from the disease commonly called necrotic enteritis, which in the past has been thought to be due to unsanitary conditions. This is in line with reports from California on the need of the pig for certain parts of the vitamin B complex.

Work along this line is being continued. *(Work, Henke)*

Figure 6.—Left, Desmanthus virgatus and right, molasses grass, two of the feeds analyzed during the year. (For Guinea grass, see cover.) The legume, Desmanthus, is high in protein.



Pineapple Sirup and Cane Molasses for Fattening. Pineapple sirup, a concentrate of pineapple juice after the removal of citric acid, may become an important byproduct of pineapple canning. In order to determine the feeding value of this sirup, an experiment was set up in cooperation with the Hawaiian Pineapple Company. Sixty pigs, averaging 62 pounds initial weight, were divided into six lots of 10 pigs each. Six rations were fed, designed to compare pineapple sirup with cane molasses at three different levels of intake. Until the pigs in all lots averaged approximately 100 pounds in weight only two levels of molasses and sirup were fed, after which time the final rates of feeding were established. In every case the energy and protein requirements were equalized by adjusting the barley and protein ingredients of the feeds. Free access to fresh green feed or alfalfa hay was permitted. The test lasted for 77 days. Results are shown in table 10.

Table 10.—Gains in weight and feed consumption of pigs fed various levels of cane molasses and pineapple sirup

Supplement: Opening level After 100 pounds	Cane molasses 10% 20%	Pineapple sirup 10% 20%	Cane molasses 20% 40%	Pineapple sirup 20% 40%	Cane molasses 20% 50%	Pineapple sirup 20% 50%
Number of pigs	10	10	9[1]	10	10	10
Average final weight ......(pounds)	149.1	157.5	150.6	161.9	143.4	160.1
Average initial weight ...... do	62.3	62.2	63.3	62.3	62.3	62.0
Average gain (77 days) .... do	86.8	95.3	87.3	99.6	81.1	98.1
Average daily gain .... do	1.13	1.24	1.12	1.29	1.05	1.27
Total feed per pig per day do	5.71	5.75	5.99	6.26	6.27	6.43
Feed per pound of gain .... do	5.05	4.64	5.35	4.85	5.97	5.06

[1] One pig was killed after 37 days, due to hemorrhoids; average daily gain in this lot was calculated on the basis of 9 pigs, and average daily feed, on the basis of 730 pig-days.

It may be seen that the pigs receiving pineapple sirup averaged 98 pounds gain in weight and that the three pens were approximately equal. The pigs receiving cane molasses gained 85 pounds, on the average. This is a difference of 15 percent in favor of pineapple sirup. The pigs making the poorest gain were in pen 5, which received 50 percent cane molasses. This would indicate that the rate of feeding was too high. Pigs in this pen also required more feed to make a pound of gain than in any other. It has been shown in previous reports that cane molasses, probably because of its high ash content, is laxative to hogs and poultry when fed in excess.

It is apparent that molasses and pineapple sirup can be used to displace barley in hog rations up to 40 percent and 50 percent of the total rations respectively. The difference in efficiency (approximately 15 percent) together with such considerations as labor and time required to bring the hogs to market weight should determine the value of pineapple sirup as compared to cane molasses. *(Work, Henke)*

Cooked Taro for Fattening. Ten pigs, averaging 56 pounds each, were divided into two lots. Pigs in lot 1 were fed all of the whole cooked taro corms they would eat, with free access to a protein supplement composed of 49 pounds local tuna-fish meal, 49 pounds soybean oil meal, 1 pound salt, and 1 pound bone meal. Lot 2 was fed a check ration composed of 68 pounds rolled barley, 20 pounds cane molasses, 10 pounds tuna-fish meal, 1 pound salt, and 1 pound bone meal. Fresh green feed was given daily to each lot.

The taro-fed pigs gained 80 percent as much as did the check lot (1.00 pound versus 1.24 pounds), and consumed 11.6 pounds taro plus 0.87 pound supplement to make a pound of gain. The check pigs required 6.1 pounds concentrate to make a pound of gain. *(Work, Henke, Tsubota*[1]*)*

Papayas for Fattening. Twelve pigs averaging 44 pounds were divided into two lots. One lot was fed ripe papayas to the limit of appetite plus the same protein supplement described above (see *Cooked Taro for Fattening).*

In this test the pigs fed the check ration made a pound of gain on 4.44 pounds of feed. The papaya-fed pigs required 31 pounds of papayas plus 1.37 pounds supplement to produce a pound of gain. *(Work, Henke, Blake*[1]*)*

[1] Senior student.

Chemistry and Soils

Mineralizable Nitrogen in Soils

The rate of mineralization of soil nitrogen is influenced by two important environmental factors—soil temperature and moisture.

Samples of four types of soils were collected at weekly intervals from the field during the past year, wetted to optimum conditions, and incubated for 3 weeks. A very close inverse relationship was found between moisture content of the soils at the time of sampling and the mineralizable nitrogen.

Three soils, in both wet and dry condition before wetting to optimum conditions, were incubated at 5-degree temperature intervals from 20° to 35° C. Wet soils incubated at 35° C. released about twice as much mineralizable nitrogen as the corresponding soils incubated at 20° C. For dry soils the increase in mineralizable nitrogen at the highest incubation temperature was only 25 percent.

The addition to soils of thiamin hydrochloride (vitamin B_1) in amounts varying from 0.0001 to 1 milligram per 100 grams of soil produced no increase in mineralizable nitrogen. *(Fukunaga)*

Nature of Organic Phosphorus in Soils

Establishing the chemical nature of the organic-phosphorus compounds in soil has long been recognized as essential to a proper understanding of the significance of soil organic phosphorus, particularly in relation to plant nutrition. In many soils, organic phosphorus is present in considerable quantities but apparently is not readily transformed into inorganic phosphates which plants can utilize.

In an attempt to identify the organic-phosphorus compounds in cultivated Hawaiian soils, inositol was isolated for the first time from organic-phosphorus-bearing soil material. The isolation of inositol from three soils indicates the presence of inositol-phosphate compounds. It is interesting to note that, whereas previous workers had reported nucleic-acid compounds in other soils, the present investigation failed to show either purine or pyrimidine bases in organic-phosphorus soil material.

An ash-free organic-phosphorus product isolated from soil gave inositol and phosphoric acid on hydrolysis. The phosphorus and nitrogen contents of the ammonium salt of this product suggest inositol monophosphate.

Quantitative estimations of inositol liberated by hydrolyzing organic-phosphorus soil material showed that inositol-phosphate compounds account for only a part of the total soil organic phosphorus. *(Yoshida)*

Soil Studies with Radioactive Phosphorus

With radioactive phosphorus, it is possible to trace the amount and rate of movement into plants of phosphates which have been applied to a soil, without interference from the native soil phosphorus.

The uptake of radioactive phosphorus by tomato seedlings grown in a series of 12 selected Hawaiian soils and in sand and water cultures was studied. Approximately 70 percent of the phosphorus added to the sand and water cultures was found in the ashes of seedlings harvested 6 days after fertilization, whereas seedlings grown in various soil cultures for 19 days after fertilization contained from 0.03 to 2.7 percent of the original radioactive phosphorus. When Sudan grass seedlings were grown on the same 12 soils, they extracted more phosphorus from certain of the soils than did tomatoes. Apparently the availability of phosphorus fertilizers mixed in soils is influenced by the species of plant grown as well as the sorption or fixing power of the soil. Subsequent studies indicate that the distribution of roots throughout the soil mass also affects fertilizer uptake.

Chemical measurements of the power of the various soils to sorb or fix phosphates from aqueous solutions paralleled results from the above-described biological method with tomatoes. However when Sudan grass was the test plant, the agreement was unsatisfactory. Apparently Sudan grass can utilize some of the phosphorus which has been fixed by the soil. *(Ballard, Dean)*

Polarographic Analyses

A polarograph (see fig. 7) was constructed for the quantitative determination of heavy metals present in small quantities in soils and plants. Investigations of methods of preparing satisfactory solutions of the substances to be analyzed are under way. A rapid, simple, and accurate procedure for determining zinc in plant tissues is being applied to a study of zinc deficiency in pineapple plants. *(Dean)*

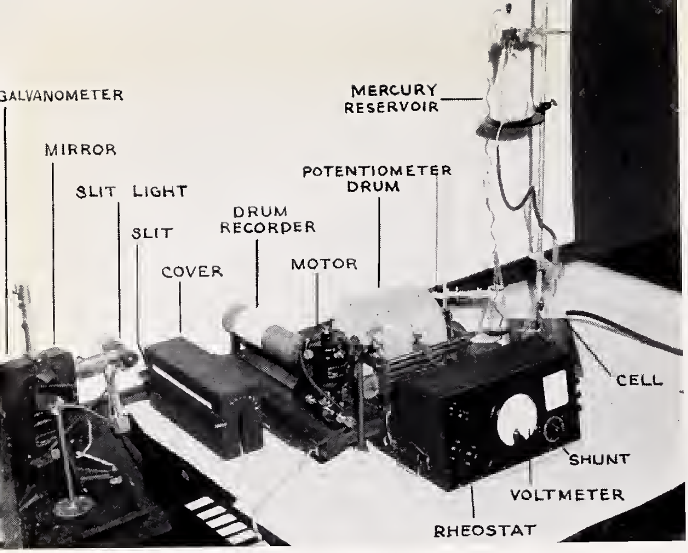


Figure 7.—Polarograph constructed in station laboratory for determination of small quantities of metals in soils and plants.

Boron Studies

The total boron content of a series of 20 representative Hawaiian surface soils was found to range from 10 to 60 p.p.m., and the available or hot-water-solution boron, from 0.2 to 2.6 p.p.m. The colorimetric method of Berger and Truog was employed. Only three of the soils investigated were in the deficient range.

In a study of the vertical distribution of available boron in profile samples, the surface soils in all instances contained at least twice as much boron as the corresponding subsoils. *(Dean, Tanada[1])*

Base Saturation of Soils

Effect on Plant Growth. Greenhouse studies to determine the effect of base saturation on growth of plants employed artificial soils composed of base exchange materials and quartz sand. The base exchange materials were of two types—clay separated from bentonite, and humus separated from high organic soils.

To date progressive inhibition of growth of Sudan grass seedlings in bentonite cultures occurred when saturation was less than 20 percent. Apparently the inhibitory effect is more marked in the case of root growth than in the case of top growth.

When base saturation was below 20 percent, normal growth of Sudan grass seedlings in sand-bentonite cultures was not obtained. Progressive inhibition occurred as the saturation was reduced below this point. *(Rosendahl)*

Sorption of Potassium and Ammonium. Soils of substantial areas of the Hawaiian Islands are in a low state of base saturation because of high rainfall. Several investigators have shown that the ability of soils to retain potassium decreases as base saturation increases. It is probable that ammonium is similarly affected by the presence or absence of exchangeable bases in the soil.

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[1] Student assistant.

In Hawaii nitrogen and at times potassium are commonly applied to cane fields through the medium of the irrigation water. The sorbability of these bases at the resulting high dilutions has not previously been studied.

A soil from a humid district where irrigation is unnecessary and one representative of the drier irrigated cane lands were treated in such a manner as to yield soil samples at various degrees of calcium saturation. The abilities of the soils thus prepared to sorb potassium and ammonium were determined.

It was found that the concentration of potassium, or of ammonium, in the percolating solutions was a factor of the greatest importance in the sorption of these salts. When the concentration was sufficiently low (N/1000), little or no sorption took place. Sorption of potassium and ammonium was found to increase as the degree of base saturation of the soil increased. The effect of this factor, however, was less than that of concentration. On acid soils sorption from the sulfates of potassium and ammonium was found to be materially greater than sorption from the corresponding chlorides. *(Ayres*[1]*)*

Coffee Investigations

Fertilizers and Yields. The fertilizer experiment with coffee trees maintained at the Fukuda farm in the Kona district was revised in January 1938 by halving each of the plots, thus making ten treatments instead of the original five. The changes in treatments and the resulting yields for the past 2 years are indicated in table 11.

From these yield data, the following conclusions were drawn: (1) Response of potash-starved trees to potash fertilization was not detected until the second year; (2) application of 80 pounds of potash per year was as effective as application of 160 pounds; (3) no changes in yield were obtained when the trees previously adequately fertilized received 80 pounds of nitrogen less or 80 pounds of potash more per year; (4) the addition of sodium chloride to potash-deficient trees had no measurable effect.

Fertilizers and Leaf Analysis. Preliminary studies of the chemical composition of coffee leaves indicate that such foliar diagnoses may serve as a valuable index to the fertilizer requirements of the trees.

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[1] Graduate student.

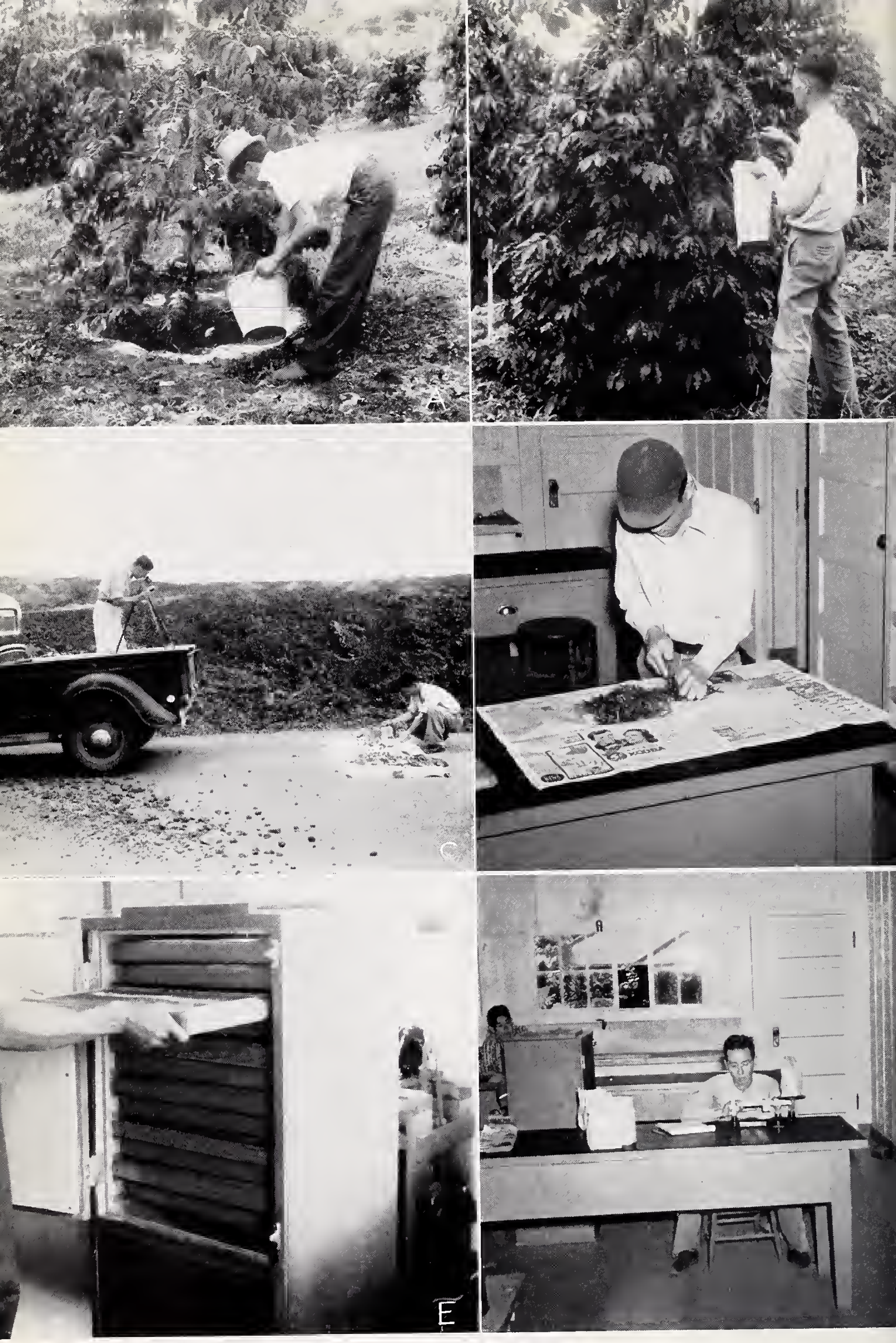

Figure 8.—The story behind coffee analyses: A, Fertilizing tree; B, picking leaves; C, photographing color of leaves; D, chopping leaf samples; E, drying samples in tray drier; and F, weighing leaf samples prior to analysis.

Table 11.—Effects of fertilizers on yields of coffee trees at Fukuda farm

Original treatment 1930-1938[1]	Revised treatment 1938-1940[1]	1938 yield per tree	1939 yield per tree
		Pounds	*Pounds*
8-8-8	4-8-8	20.8	31.3
	8-8-8	21.1	37.0
8-0-0	8-4-0	1.1	1.8
	8-4-0 and NaCl	2.8	3.9
0-0-0	0-4-8	4.2	20.4
	0-4-4	3.7	19.3
8-8-0	8-4-4 and NaCl	3.4	17.5
	8-4-4	2.5	22.5
8-0-8	8-0-8	26.1	31.7
	8-0-12	20.9	33.3
Standard error of difference		3.5	5.0

[1] Fertilizer mixtures indicated were applied at the rate of 2,000 pounds per acre per annum.

The leaf samples are compared with a color chart devised at this station before being analyzed for total nitrogen, nitrate nitrogen, and total potash (see fig. 8). *(Dean, Fukunaga, Beaumont)*

Entomology

Insect Surveys

Surveys of the insects of important crops have included records of occurrence, severity of attack, and distribution. To date, most of this work has been done on the island of Oahu, where acreages are greatest of the particular crops first selected for study. The major pests of beans, papaya, and Irish potatoes have now been determined.

Garden Bean. Insects of major importance, observed chiefly on the popular green-podded pole varieties, are listed below:

The Chinese rose beetle *(Adoretus sinicus),* when abundant, skeletonizes the foliage.

The bean pod borer *(Maruca testulalis)* bores into blossoms, pods, and stem. Attacks on blossoms and pods cause complete destruction of these parts or result in unmarketable, deformed pods; attacks on larger pods render them unsalable. The insect is not widespread, but in those sections in which it occurs it is very destructive during the warmer months.

The bean leaf hopper *(Empoasca solana)* is widespread on Oahu but is most abundant in hot, dry sections such as Lualualei; it feeds by sucking the sap from the undersurfaces of the leaves and causes "hopperburn."

The bean capsid or squash capsid *(Pycnoderes quadrimaculatus)* is another leaf-sucking bug which feeds on the undersurfaces of the leaves.

The bean or cowpea aphid *(Aphis medicaginis)* is occasionally abundant on foliage, stems, or pods.

Two species of mite are destructive to beans; a white mite (a tarsonemid species) attacks and causes deformity of young foliage, and a "red spider" *(Tetranychus* sp.) occurs on the undersurfaces of the leaves.

Papaya. The most important pests of papaya are mites. The white mite (a tarsonemid species) causes leaves to be distorted, leathery, crinkled, yellowish in color, and much reduced in size (see fig. 9).

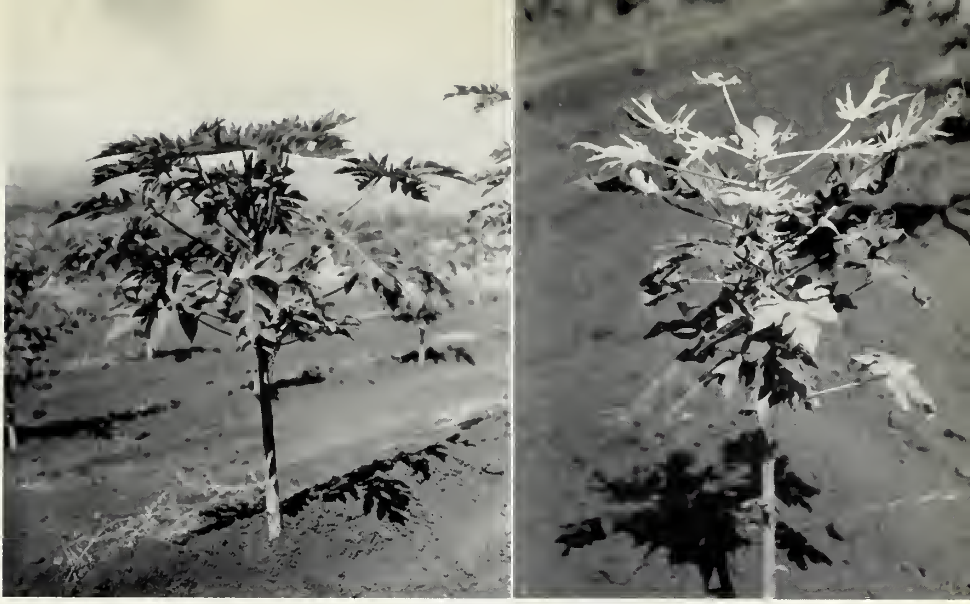

Figure 9.—Left, normal papaya tree; right, typical distortion of leaves caused by infestations with white mites [Hemitarsonemus latus (Banks)].

Heavy infestations may kill the leader or the entire tree. "Red spider" *(Tetranychus* sp.[1]) is the commonest pest of both young and mature trees. It is particularly abundant in hot, dry regions or during periods of low rainfall. Infested trees are unthrifty, the leaves acquire a blotchy, yellowish color, and fruit may be scarred.

Next to mites in importance are various sucking insects. Although these are in general not abundant, one or more species may be vectors of papaya mosaic (see annual report for 1939, pp. 37 and 69). The onion thrips *(Thrips tabaci)* and the green peach aphid *(Myzus persicae)* are the commonest sucking insects, although their occurrence is patchy and sporadic. Tissue derangement follows heavy infestations.

Irish Potato. Major insects observed on potatoes at Poamoho farm (elevation 700 feet) include foliage feeders, sap-sucking insects, and stem and tuber insects. Relative abundance of the respective species varies with season and from year to year so that it is difficult to say which species should be considered the most important. Tuber moth *(Gnorimoschema operculella)* is important during the warmer months.

During the winter months when potato production is greatest, foliage destruction may be caused by grasshoppers *(Conocephalus saltator* and *Oxya chinensis)*, beet armyworm *(Laphygma exigua)*, or garden looper *(Autographa chalcites)*. The importance of cutworms which attack foliage, stems, and tubers varies from year to year. The green potato aphid *(Macrosiphum gei)*, the cotton aphid *(Aphis*

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[1] At least three species of Tetranychidae have now been distinguished.

gossypii), and the green peach aphid *(Myzus persicae)* are the most important sap-sucking insects. Predators and parasites occur in the field, but inclusion of an insecticide such as nicotine sulfate in the routine spray is essential for control. *(Holdaway, Look)*

Bean Pod Borer

Varietal Susceptibility. In a test comprising 15 varieties of pole beans, a considerable range in susceptibility to pod borer was found. While routine pest control measures reduced damage to some extent, the Japanese variety, Kabuto, resistant to rust, appeared least susceptible to pod borer, and a strain of Kentucky Wonder, also resistant to rust, appeared most susceptible.

Chemical Control. In continuation of work begun by Parris and Kikuta on the control of Chinese rose beetle (annual report for 1937), a field experiment has been carried out with a spray of tetra methyl thiuram disulphide, now procurable commercially as "Japanese beetle spray." The variety of bean was Morse's 191, a pole variety highly resistant to rust but very attractive to pod borer as well as to the rose beetle. The spray was applied at a strength of 2½ pounds per 100 gallons, at weekly intervals. During the period of maximum growth of the plants, the spray was applied at intervals of 4 to 5 days. A commercial preparation of pyrethrum and rotenone was used to control leaf hoppers and aphids in both the spray-treated and check plots during the major portion of the period of spray application. Reduction of damage by the rose beetle was slight, but there was a marked reduction of damage by pod borer *(Maruca testulalis)*.

The following conclusions have been drawn from the study:

1. A high proportion of culls resulted from damage by pod borer; the culls were either deformed through attack of the borer on the young pods or contained evidence of fresh attack (see fig. 10).

2. The total yield (marketable pods plus culls) was 22.5 percent greater in the experimental plots than in the check plots.

3. The marketable crop was 58.5 percent higher in the sprayed plots than in the check plots.

4. During the peak of harvest the percentage increase in crop of sprayed beans over check-plot beans reached 75 percent on the basis of total yield and 190 percent on the basis of marketable pods.

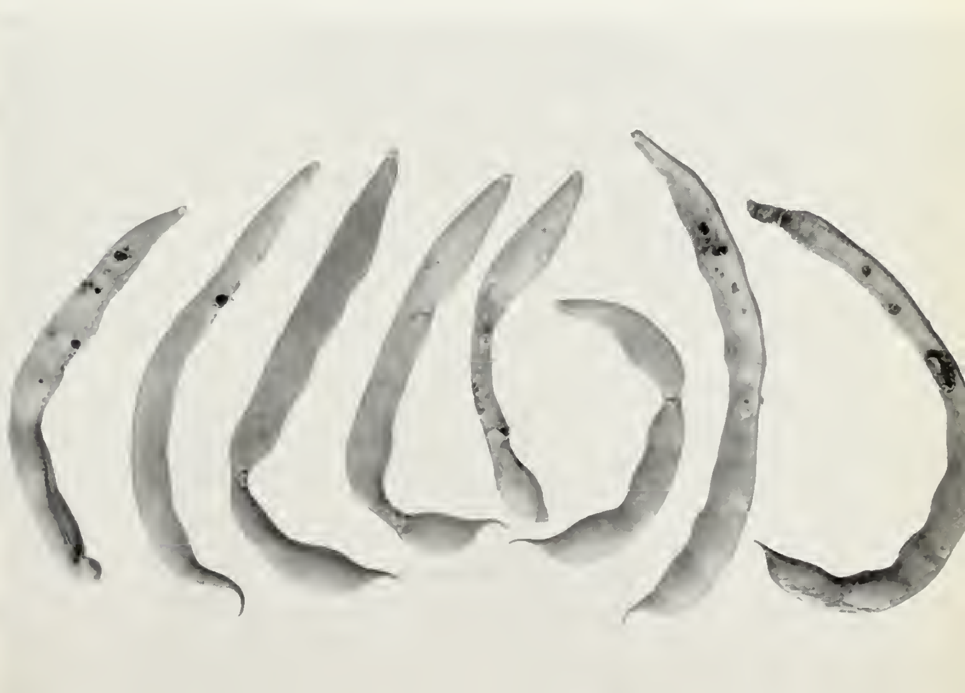
Tetra methyl thiuram disulphide is compatible with the insecticides likely to be used on beans and apparently exerts some control on the mites which infest the bean plants. *(Holdaway, Look)*

Biological Control of Cabbage Worm

Cabbage is attacked by several destructive insects, the most important of which is the cabbage worm *(Pieris rapae)*. At the present time it is necessary to spray or dust to control cabbage worm. An additional biological check in the nature of an efficient parasite would reduce losses and production costs. In a survey, made during the autumn and early winter, involving 2,670 individuals in 38 collections from 5 islands, *Apanteles glomeratus* and *Frontina archippivora* were the only parasites of significance operating on cabbage worm. Parasitism by *A. glomeratus,* the most efficient parasite of cabbage worm in Hawaii, was negligible at elevations under 1,000 feet except on Kauai, where 27-percent parasitism was found in 648 larvae.

A "wilt" disease, possibly virus in nature, was responsible for high mortality of cabbage worms, particularly at elevations of less than 1,000 feet. In many places where wilt occurred, parasitism by *A. glomeratus* was nil, while the maximum parasitism, 95.7 percent, was recorded from a place where "wilt" disease was not recorded (elevation 2,100 feet).

Figure 10.—Deformed pods of the garden bean, resulting from attack by the bean pod borer (Maruca testulatis).



Presence of "wilt" disease in the host larva affects parasitism by *A. glomeratus* through the parasite larvae, which die if the host larva is affected by wilt. On the other hand larvae of the Tachinid fly parasite *Frontina archippivora,* if well developed when the host succumbs to the disease, are able to emerge from diseased host larvae.

Results obtained at another season (see annual report for 1939) and supported by those obtained in the survey under discussion, indicated that the fly parasite, *F. archippivora,* is affected less by insecticides than is *A. glomeratus.* These results and those which show that mortality from wilt disease is less in *F. archippivora* indicate the desirability of securing, if possible, an efficient parasite in the family Tachinidae. *(Holdaway, Lucas)*

Corn Earworm on Tomatoes

The corn earworm *(Heliothis armigera)* is the most important insect attacking tomatoes in Hawaii, often causing losses of 50 percent or more and necessitating intensive spray measures. It apparently breeds throughout the year at elevations from sea level to 2,000 feet. The presence of corn in the vicinity of tomato crops appears to be a major factor in producing heavy infestations in tomatoes.

There are apparently no parasites specific to corn earworm. Such parasites as have been reared from it *(Hyposoter exiguae, Frontina archippivora, Euplectrus platyhypenae,* and *Pristomerus hawaiiensis)* account for a very low percentage mortality; they are primarily parasites of other lepidopterous insects, particularly the armyworms, and have been obtained from earworms attacking tomato and potato. To date no parasites have been reared from larvae attacking corn. *(Holdaway)*

Ecology of the Tomato Bug

Continued observations on the tomato bug *(Cyrtopeltis varians)* during the past year confirm the general remarks made in the last annual report to the effect that the bug is abundant in hot, dry regions and not in cool, moist regions. The following plants have been added to the list of hosts: long squash, watermelon, dishcloth gourd, and the hairy morning glory *(Ipomoea pentaphylla).* On morning glory and dishcloth gourd, as on tomato, the bugs produced feeding scars. Although no other host plant yet recorded produces populations comparable to those sustained by tomato, morning glory to date ranks next to tomato. In view of the fact that tomato is apparently the only plant on which large populations develop, a cessation of tomato production is advised in hot, dry regions during the summer months when the bugs are most numerous and production is most hazardous from other factors. There is evidence that such a cessation of tomato production, particularly when associated with judicious crop rotation, will do much to control the bug population.

Observations made at Poamoho (700 feet) showed that bugs on tomato plants infested with aphids attacked the aphids and not the tomato stems. *(Holdaway, Look)*

Abundance of Aphis gossypii

For the past two years observations have been made on changes in abundance of *Aphis gossypii* on hibiscus at the University campus. This aphid is one of the most important economic species in Hawaii. It attacks cucurbit crops, potato, tomato, and many other plants and is the vector of several virus diseases of economic plants. There are two main peaks of abundance, one in the autumn and the other in the spring. Seasonal changes in temperature and relative humidity are small and show no correlation with changes in abundance of the aphids. There is no major correlation between aphid abundance and rainfall although observations made in 1939-40 suggest that rainfall, or lack of rainfall, may play a part. The most important factor is apparently amount of sunlight. High amounts of sunlight and low amounts both operate to decrease aphid abundance. The optimum appears to be in the vicinity of 5,000 foot candles per day.

Sixteen species of predator have been observed as exerting an effect on the abundance of the aphids; the lady bird, *Coelophora inaequalis* was the commonest. The Braconid parasite *Lysiphlebus testaceipes*, which has been considered an efficient parasite both in Hawaii and elsewhere, was present during only a few months each year. The evidence suggests that it is neither an abundant nor an efficient parasite at the scene of the observations. *(Holdaway, Lucas)*

Miscellaneous Crop Insects

Miscellaneous insects which have damaged crops during the past year are discussed briefly below:

Murgantia histrionica (Harlequin cabbage bug). Distribution of the cabbage bug is apparently still restricted to the region of Oahu extending from Ewa to Lualualei. It has been recorded from Nanakuli in this region. Another crop, daikon, has been found to be attacked. The Board of Agriculture and Forestry has introduced an egg parasite *(Ooencyrtus johnsoni)* from California and has liberated it in the infested area.

Nysius nemorivagus. During the past year this insect was recorded breeding abundantly on Chinese cabbage and cucumbers in the Kilauea Volcano district of Hawaii (4,000 feet) during October, February, April, and May, and on Chinese cabbage at Kona, Hawaii. At Kilauea it also attacked hard-skinned squash. At Kona adults were found in numbers around roots of *Solanum nodiflorum* in Chinese cabbage fields. Only once before has this Lygaeid been recorded attacking an economic plant. In June 1933 Dr. M. B. Linford found it attacking the terminal shoots of Irish potato plants on Parker Ranch, Hawaii, at an elevation of 5,850 feet.

Laphygma exigua (beet armyworm). Beet armyworm caused considerable damage to a number of crops during the past year, especially on Oahu but also at Kahaluu, Kona, Hawaii. Broccoli, pea, Chinese pea, Chinese spinach, head cabbage, Irish potato, and tomato are crops recorded as being damaged markedly. The damage occurred over a wide range of climatic conditions from very dry and hot to moderately moist and cool. *(Holdaway, Look, Lucas)*

Insects Not Formerly Recorded in Hawaii

The following insects, not previously reported as occurring in Hawaii, have been recorded:

Amphorophora sonchi on tomato, Lualualei, Oahu

Autographa brassicae (cabbage looper) on cabbage and cauliflower, Oahu, Maui, Molokai, and Kauai

Micromyzus formosanus (onion aphid) on chives and Japanese onion, Kaneohe and Waipahu, Oahu

Myzus circumflexus (lily aphid) on papaya and rose, Koko Head, Kailua, and Honolulu, Oahu

Rhopalosiphum pseudobrassicae (turnip aphid) on broccoli, Chinese cabbage, and tomato, Waipahu, Kipapa, and Kaneohe, Oahu. *(Holdaway, Look, Lucas)*

New Host Records for Hawaii

The following host records of economic insects have not formerly been made in Hawaii:

Amorbia emigratella (Mexican leaf roller) attacking broccoli, papaya, peanuts, potato, and tomato

Aphis maidis (corn leaf aphid) breeding on papaya and tomato

Aphis medicaginis (bean or cowpea aphid) breeding on asparagus in tips

Aphis middletoni (Erigeron root aphid) breeding on papaya and tomato

Empoasca solana (bean leafhopper) in abundance on lettuce and on peanuts

Heliothis armigera (corn earworm) larvae attacking foliage of Chinese peas, fruit of eggplant, fruit of Italian gourd, foliage of carrot, head lettuce and pods of lima beans. No adults emerged from larvae which fed on lettuce. *(Holdaway, Look, Lucas)*

Horticulture

Truck Crops

Asparagus. Winter temperatures in Hawaii are high enough for continuous growth of asparagus, and the plant goes through no dormant period. Small commercial plantings in recent years have shown rapid decline in plant vigor and resultant small spears. Limited quantities that have been grown for out-of-season (winter) shipment to the mainland have commanded high prices, however. Crowns of the Mary Washington variety were planted in the summer of 1939 at Poamoho farm to secure data on time of harvest (season), length of life, spear quality, spacing, and sex.

Snap Bean. Pole varieties. The Kentucky Wonder Rust-Resistant Brown-Seeded variety is highly resistant to the rust found in Hawaii, and crosses have been made with the popular rust-susceptible, flat-podded variety Lualualei. These crosses have now been carried to the second or segregating generation and selections combining desirable commercial characters and rust resistance are being made.

Bush varieties. In a test of bush snap beans, the following varieties gave satisfactory yields of good quality beans: Bountiful, Black Valentine, Commodore, Giant Stringless Green Pod, and Hawkesbury Wonder.

Tomato. Tests of the performance of many varieties of tomatoes have been conducted at Waipahu, Oahu, since 1936. Marglobe, Pritchard, and Break O'Day, among the standard varieties, have given good yields of high quality fruits where spotted wilt and corn earworms were not limiting factors. Cooperative work with the pathology department in testing and selecting tomatoes for resistance to spotted wilt is in progress (see p. 67). The disease is extremely destructive, and breeding for resistance appears to be the most logical attack for the horticulturist.

Lettuce. Observations in the past few years have shown that good quality head lettuce cannot be produced at lower elevations throughout the Territory in summer. Variety tests in midwinter (1939-40) at Waipahu included the Imperial strains 847, 152, and 44. Large heads of medium firmness were produced by all three varieties, but Imperial 847 appeared slightly more desirable than the other two. These trials will be repeated.

Celery. A test planting of celery varieties was grown near Waipahu in the winter of 1939. Crispheart and Utah Green produced the highest quality plants. It was apparent that temperatures in winter at this location were favorable to fair quality. The varieties were planted for a summer test, also, but failed to produce a marketable product. Further testing of the crop in various localities is desirable to determine seasonal requirements.

Cauliflower. During the past year several varietal tests were planted near Waipahu, to determine growth behavior in different seasons at this low elevation. It was found that the popular mainland variety, Snowball, gave a satisfactory crop in the winter season, but only Early Market and Early Benares, secured from India, were successful in the warmer weather of late spring. Temperatures are too high in summer for production of good quality cauliflower at low elevations. *(Sumida, Tachibana)*

Potato

Variety Tests. Variety tests have been continued at Poamoho farm. No variety appears superior to Bliss Triumph or British Queen, the two now being grown on most of the commercial acreage. Resistance to early blight would be particularly desirable, and further acquisitions will be tested for this character.

Culture. In a spacing test at Poamoho, distances between plants in the row were 9, 12, 15, and 18 inches. Highest yields were obtained from 12-inch spacing. Wider spacings gave larger tubers, but the average number per plant was smaller and yields were lower. The 9-inch spacing gave tubers too small to be commercially desirable. These results agree with work of the previous year, and this phase of cultural studies will be discontinued.

Fertilizer Placement. A fertilizer-placement test comprised the following practices: (1) Continuous bands 2 inches below and 2 inches on each side of seed pieces; (2) continuous bands 2 inches above and 2 inches on each side of seed pieces; (3) continuous bands on level with seed pieces and 2 inches to each side; and (4) fertilizer thoroughly mixed with soil in row before seed pieces were dropped.

No statistically significant differences were found among treatments 1, 3, and 4. Treatment 2 gave a lower yield. Overhead irrigation was provided when necessary. *(Sumida)*

Seed Storage. Importation of seed for the production of winter crops of potatoes has been the accepted practice for many years. Investigations to determine the possibility of using home-grown seed have been under way for 3 years. Virus diseases—spindle tuber, spotted wilt, and mosaic—make difficult the maintenance of healthy seed stock in the Territory over a period of years. However, importations can be reduced to the quantity necessary to grow the seed stock for the following year. Seed stocks only one generation away from imported seed yield as well as newly imported seed when properly stored. Seed imported from North Dakota, grown at Poamoho, Oahu, and stored at various temperatures were then replanted at Poamoho with the results shown below:

Storage conditions	Yield per 50 plants[1]
° *F.*	*Pounds*
36	19.4
38	26.8
40	18.9
50	23.0
Newly imported (no storage)	24.4

[1] A difference of 2.9 pounds is required for significance.

From the above data it is seen that no significant differences in yield occur between island-grown seed potatoes stored at 38° F. or 50° F. and newly imported seed. Long sprouts are produced during storage at 50° F., however, so that temperature is not recommended. These results confirm earlier reports that a 38° F. storage temperature is best for island-grown seed potatoes. *(Jones, Sumida)*

Seed Treatment. Dormant Bliss Triumph seed potatoes have been treated with ethylene chlorohydrin as a possible method of breaking dormancy of newly harvested potatoes brought to the islands for October and early November planting. Excellent results in breaking dormancy have been secured with liquid ethylene chlorohydrin at the rate of 0.8 cc. per kilogram of potatoes. The tubers were placed in an enclosed container with the fluid for 2 or 3 days at approximately 27° C., then stored for 13 days before planting. Ethylene chlorohydrin

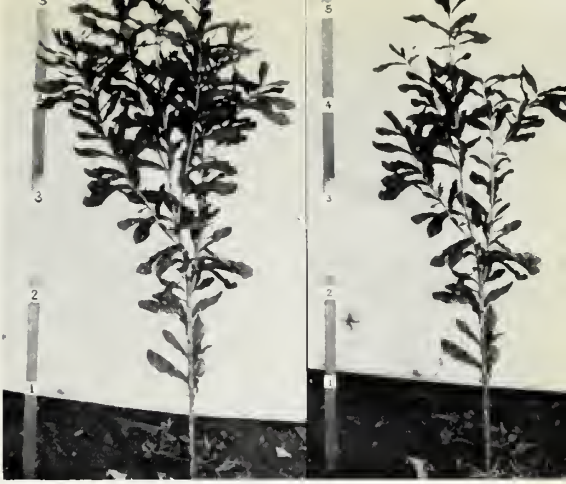


Figure 11.—Left, young macadamia tree, before pruning; same tree right, after central-leader pruning.

increased the number of stems per hill, and increased yields were due to larger numbers of tubers rather than larger size of tubers. *(Michener)*

Macadamia

Chlorosis. In several localities on the island of Oahu, the vigor of the macadamia is seriously affected by a chlorosis. At Nutridge many trees of bearing age have died. At Poamoho, Kailua, Waipahu, and Pensacola the disease has attacked nursery stocks and young transplanted trees. In other commercial orchards and nurseries the chlorosis has not appeared.

At Nutridge, chlorosis occurs in a rather clearly defined area, suggesting that a soil factor is involved. However, green trees do occur adjacent to diseased trees in the chlorotic area. Chemical analyses of the soils of chlorotic areas revealed higher pH's and greater quantities of phosphorus, calcium, potassium, and magnesium than were found in green areas.

Leaves from green trees were considerably higher in manganese, calcium, reducing and non-reducing sugars, and slightly higher in dry matter, iron, and acid-hydrolyzable materials than were leaves of chlorotic trees. Conversely leaves of chlorotic trees were considerably higher in ammonia, amid and amino nitrogen, and slightly higher in magnesium, phosphorus, and potassium.

Seeds from 75 accessions in the Nutridge orchard were planted at Kailua, Oahu, and in sand cultures at the Pensacola station. Observations so far have shown that (1) the progenies of green trees in chlorotic areas react more like the progenies of chlorotic trees than like the progenies from green trees in nonchlorotic areas; (2) the initial growth of seedlings from certain accessions was largely chlorotic but subsequent growth was green; (3) initial growth of seedlings from other accessions was green while later growth was chlorotic; (4) two accessions produced green seedlings in such numbers as to appear resistant to chlorosis; and (5) normal green seedlings appeared in every progeny.

Estimation of chemical constituents (potassium, calcium, magnesium, phosphorus, iron, and manganese) of seeds from 22 macadamia accessions showed that only the iron content was significantly associated with chlorosis of the seedlings. *(Guest)*

Variety Tests. Twenty-five clonal varieties of macadamia were set out during the year in four different areas on Kauai. Insofar as was practicable, the plantings were patterned after similar tests established in 1938 and 1939.

About 80 varieties are now planted in orchard form, each variety occurring in at least two locations. All of the plantings are growing satisfactorily with the exception of one at Poamoho farm, where many of the trees have become chlorotic. *(Guest)*

Culture. Tests to study the influence of rough-shell and smooth-shell rootstocks upon growth of rough-shell and smooth-shell varieties were established at Waipahu and at Poamoho farm. Replicated plantings include three selections of each type grafted on each of the two rootstocks.

The central-leader system of training young macadamia trees is being tested. The objective is to prevent formation of more than one scaffold branch at any point on the central leader, thus reducing limb breakage when the tree becomes large. Figure 11 illustrates this method of pruning, which is being practiced in all of the varietal and cultural plantings on Hawaii, Maui, Oahu, and Kauai. *(Guest, Minn)*

Nursery Propagation. In grafting macadamias, it was found that the percentage of "takes" from certain trees was low even though the scions were selected from branches which had been ringed to force carbohydrate storage. A preliminary investigation of the possible cause of this erratic behavior was made. Branches were ringed on 20 mature trees in a commercial orchard. After 5 weeks little or no starch (as indicated by the iodine test) had accumulated in scions from 5 trees, only a moderate amount in scions from 9 trees, and starch was abundant in scions from only 6 trees. Unringed branches on both the low- and high-starch trees had little or no starch. The percentage of "takes" was in approximate proportion to the relative

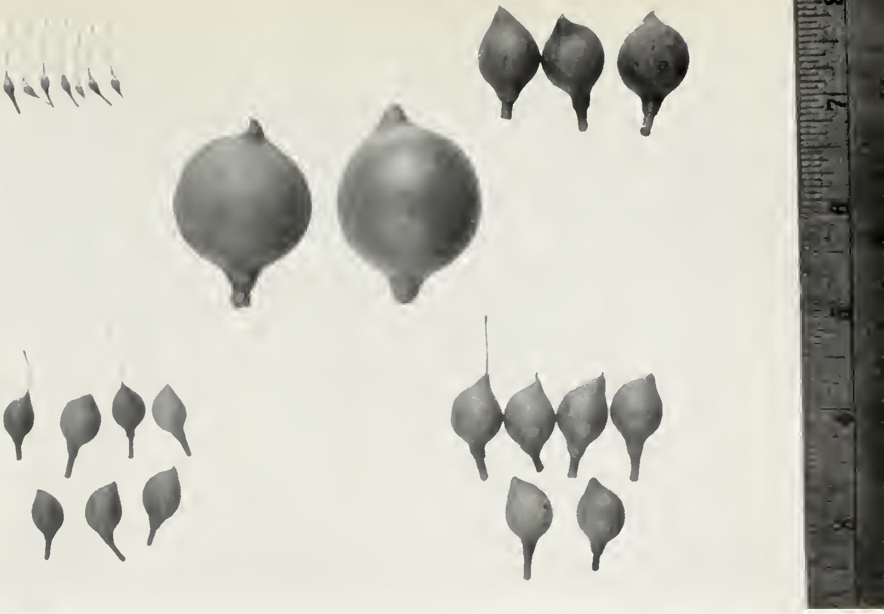


Figure 12.—Macadamia fruits collected from ground under tree, illustrating different stages of maturity at which dropping occurs.

amount of starch in the scions. These results reemphasize the importance of carbohydrate storage in scions and suggest that mature seedling macadamia trees will vary in the rate at which carbohydrate materials accumulate after ringing. *(Guest, Minn)*

Pollination. One of the outstanding characteristics of *Macadamia ternifolia*, and of all the *Proteaceae*, is the small percentage of flowers which set fruit. The number of flowers on a raceme varies from 200 to 300, while the number of mature fruits per inflorescence is usually only 2 or 3 and a large number of racemes will set no fruit whatever. Some trees are more fertile than others, however.

Almost immediately after anthesis there is a severe drop of flowers which removes 50 percent or more of the total. During the next few weeks, large numbers of pistils which have undergone only slight development will fall. Later, pistils which reach the size of one-eighth to three-eighths inch in diameter and 3 months of age may fall (see fig. 12) . The few fruits that remain will usually mature.

Inherent fertility is often indicated by the condition of the pollen. In macadamia the percentage of poor or aborted pollen on certain trees is greater than on others but is never high. This factor can be of little importance in controlling fruit setting.

Cross pollination is effected by insects, principally bees, which visit the flowers at the time when nectar is produced in large quantities. Upon opening of the flower the perianth segments with the adnate anthers roll back and release the club-shaped style on the tip of which has been deposited the pollen from the 4 anthers. The stigma is not receptive at the time and this protandrous condition suggests that cross pollination is desirable if not essential for fertilization. The pollen, which is in clustered masses on the style, is carried or scattered by insects in their search for nectar. All flowers on a raceme do not open at once so that the inflorescence may be visited by insects several times on 2 or 3 succeeding days. Climatic conditions during the period of anthesis undoubtedly affect pollination.

The stigma of the pistil is very small and consists of papillate-secreting cells lining the one-sided orifice in the tip of the style. These cells spread open slightly, after anthesis. The pollen grains become lodged between them and germinate. Because of the smallness of the stigmatic surface the pollen must be deposited in a very exact manner if it is to function. Failure of the pollinators to do this is undoubtedly a limiting factor in fruit set.

Whether or not self- or cross-incompatibility exists among macadamia trees is also under investigation. Selfing different individuals has shown that some trees are completely self-incompatible and others are partially so. Crosses between different trees were not extensive or conclusive enough to establish definite cross-relationships, but the indications are that cross-incompatibility does exist between some individuals. *(Hartung)*

Oil Characteristics. Data on the accumulation of oil in the macadamia embryo during growth and ripening have been published, and studies of the changes in oil characteristics are in progress. The physical properties of oil from mature nuts are: acid value, 0.23; saponification value, 196.8; soluble acids, 0.015; iodine number, 75.6; insoluble acids, 88.5; and unsaponifiable matter, 0.31. Some of the properties of oil from very young nuts are: acid value, 108; saponification value, 422; and iodine number, 17.38.

These values indicate that a large drop in free fatty acids, an increase in the length of the fatty acid chain, and an increase in degree of insaturation occur during the development of the embryo. *(Jones)*

Genetics of Sex Determination in Papaya

Studies on the genetics of sex inheritance in papaya begun in 1936 and first reported in the 1938 annual report have recently been brought to completion.

In bulletin No. 32, issued by this station in 1914, J. E. Higgins and V. S. Holt described 13 sex forms in papaya. The authors failed to recognize, however, that a given male or hermaphrodite tree might appear as a particular form at one season and as a different form at a later season. From continuous observations over a period of several years it is now possible to combine various sex forms into classes of genetic sex types. The designations of the four classes now recognized and the sex forms, described by Higgins and Holt, which each class combines are given below.

Type I —female or pistillate—Form 1.
Type IV —fully-fertile hermaphrodite—Forms 7, 8, 9, 11, 12.
Type IV+—summer-sterile hermaphrodite—Forms 4, 5.
Type V —male or staminate—Forms 2, 3, 6, 10, 13.

The sex type corresponds essentially to the designation previously given to the flower type[1] predominating upon the trees during the late summer and fall months. There is no type II or type III class because no tree bears predominantly type II or type III flowers during the greater part of the year. Insofar as is now known, the type III flower is an expression of independent genetic factors for pistilloidy superimposed upon type II or type IV flowers. The type IV+ flower, not previously described, appears to be a type IV in which a functional pistil fails to develop.

Genetic studies have shown that each sex type remains an entity in inheritance. The sex expression of each is probably determined by complexes of closely associated genetic factors which are always carried together from generation to generation. These complexes, therefore, are inherited as if they were simple Mendelian units. The Mendelian ratios are modified, however, because of the nonviability of one-fourth of the seeds in fruits taken from hermaphrodite and male trees.

While each sex complex gives rise to a specific genetic sex type, each sex type is subject to modification within fairly well defined limits as a reflection of physiological influences. Thus, many of the sex forms of Higgins and Holt are actually only variant seasonal expressions of the sex type. *(Storey)*

[1] Storey, W. B. *Proc. Amer. Soc. Hort. Sci.* 35: 83-85. 1938.

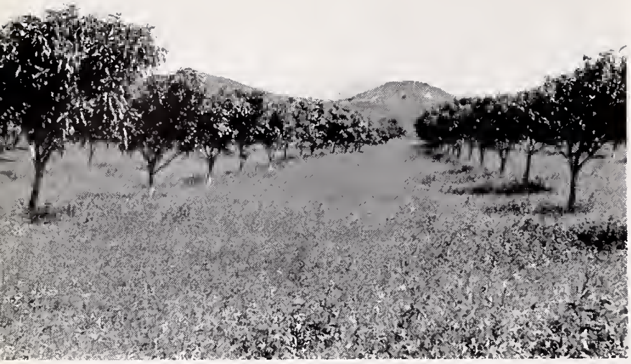


Figure 13.—Young mango orchard of D. T. Fleming, station collaborator; the trees are used for breeding and girdling experiments.

Mango Variety Tests

Eighteen varieties of mango were set out in a test planting at Poamoho farm. The trees were planted on the contour according to a plan worked out in cooperation with the Soil Conservation Service of the United States Department of Agriculture. The varieties were: three trees of Cowasjee-Patel, two of No. 9, two of Whitney, three of Victoria, three of Bishop, three of Alphonse, three of Ameeri, three of Bombay Yellow, three of Wooten, two of Paris, three of Mulgoba, three of Fairchild, three of Itarmarca, two of Julie, two of Lott's, two of Saigon, seventeen of Pirie, and seventeen of Haden. The Pirie and Haden are planted in such a manner that they can be used in a cultural test.

Through collaboration with Mr. David T. Fleming, of Lahaina, Maui, much valuable information is being obtained on the relative commercial importance of mango varieties as well as on growth and fruiting habits. The young orchard shown in figure 13 is being used for breeding and girdling experiments. *(Fleming, Guest)*

Vapor-Heat Treatment of Fruits and Vegetables

Effect of Relative Humidity on Respiration of Papayas. It was reported last year that papayas may be severely injured when subjected to a temperature of 110° F. and a relative humidity of 100 percent for 16 hours or longer, while at a relative humidity of 60 percent, no injury was visible. During the past year the respiration of the papaya during heat treatment has been studied in an effort to explain this phenomenon.

It was found that carbon-dioxide production of papayas held at 100-percent relative humidity reached a higher peak at a later time during treatment than did papayas held at 60 percent, and the rate of carbon-dioxide production then fell away more rapidly. This differential behavior is apparently a result of injury caused by the higher humidity, although the fundamental factors are not clear. The lower water content of fruits treated at low humidity, with a consequent increase in rate of transpiration, undoubtedly plays a part. *(Jones)*

Catalase Activity in Papayas. Catalase activity, like carbon-dioxide production, is an index to maturity of the fruit and to injury occurring during the vapor-heat treatment. When normal, untreated papayas were tested, the catalase activity for mature-green fruits, as indicated by cubic centimeters of oxygen produced in 5 minutes, was found to average 23.4; for firm-ripe fruits, 18.5; and for ripe fruits, 15.7.

The effect of the vapor-heat treatment on catalase activity was determined when the air was fully saturated and when the relative humidity was held at 60 percent during the first 8 hours, or approach period. The fruits were held at room temperature for 32 hours after completion of the treatment.

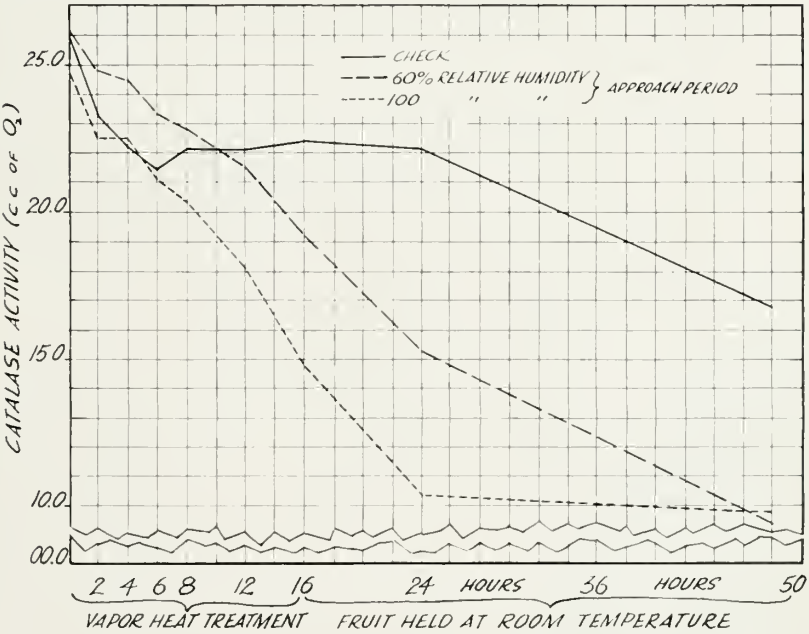


Figure 14.—Catalase activity of papaya fruits treated with vapor heat, showing effect of lowered relative humidity during approach period when fruits are being brought to the specified treatment temperature.

Figure 14 illustrates how much more rapidly catalase activity declined in treated fruits than in check fruits. Moreover, the decline was more rapid when the air was fully saturated throughout treatment. *(Ikeda, Jones)*

Treatment of Other Fruits and Vegetables. Investigations on the vapor-heat treatment of eggplant, litchi, Chinese peas, green snap beans, yellow wax beans, lima beans, cucumbers, tomatoes, and bell peppers were also conducted during the year and have been reported in station circular No. 16. *(Jones)*

Methyl-Bromide Fumigation

Methyl-bromide fumigation, when approved by the U. S. Bureau of Entomology and Plant Quarantine,[1] will offer a third method whereby fruits and vegetables may be treated for export. Investigations on the effect of this treatment on papayas have been in progress. The papaya is not completely tolerant to methyl bromide at the specified concentration. This is indicated by a decreased rate of ripening, decreased catalase activity, and decreased resistance to decay organisms (see fig. 15). *(Jones)*

Colchicine Experiments

Cuttings of *Calotropis gigantea* and *Jasminum sambac* and seeds of *Psidium cattleianum, Dracaena* sp., and *Hibiscus* sp. were treated

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[1] Approved as of August 1, 1940, for guava, papaya, bell pepper, bitter melon, cucumber, summer squash, string bean and tomato. Prescribed treatment: 2 pounds of methyl bromide per 1,000 cubic feet for 3½ hours, at a temperature of not under 80° F.

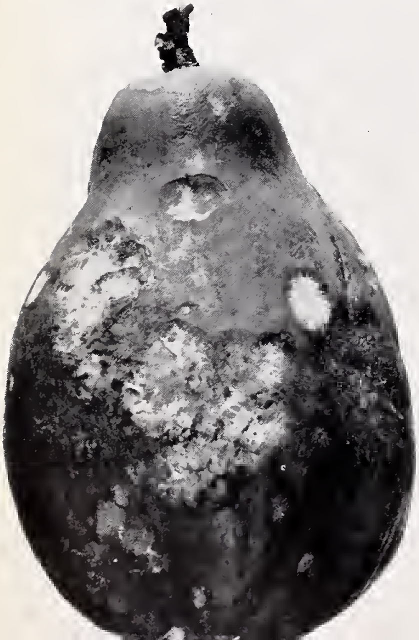


Figure 15.—Effect on papaya of Colletotrichum gloeosporioides, the chief decay organism attacking methyl-bromide treated fruits.

with colchicine without inducing the development of polyploid tissue. Initial stunting and abortion of the first new leaves were later outgrown. Seeds and seedlings of *Carica papaya* were treated with colchicine and indole-acetic acid. The drugs were applied to decapitated stems from which axillary buds were also removed. All the plants, including the decapitated and disbudded checks, died back to the first node, at which point a callus was formed and normal growth was renewed. Cotyledons and hypocotyls of seeds soaked in colchicine solutions were thickened and growth was checked temporarily, but the effects were eventually overcome.

The dwarf polyploid papaya plant which resulted from an experiment reported last year maintained its polyploid characteristics. The few female flower buds produced dropped before reaching anthesis. Attempts are being made to propagate this tree by cuttings and a graft. *(Hartung)*

Plant Introductions

Table 12 lists the seed and plant introductions made during the year.

Table 12.—Seed and plant introductions made during the year ending June 30, 1940

Scientific name	Number of varieties	Source	Type of material
Bouea burmanica	1	Saigon (through D. T. Fleming)	Seed
Carica papaya	1	Board of Agriculture & Forestry (through F. Tong)	Seedlings
do	4	Maui, Florida, and Java	Seed
Cinchona succirubra	1	Hamakua, Hawaii	do
Citrus sp.	1	(Through Paul Guest)	Scions
Cola acuminata	1	Summit, Canal Zone	Seed
Garcinia mangostana	1	(Through D. T. Fleming)	do
Lansium domesticum	1	Java (through D. T. Fleming	do
Litchi chinensis	2	(Through B. D. Pratt)	Airlayers
Mangifera indica	4	Manila, P. I.	Scions
Nephelium kopoesalan	1	do	do
rambutan	2	do	do
Physalis ixocarpa	1	New South Wales, Australia	Seed

Nutrition

Analyses and Vitamin Assays of Macadamia Nuts

Samples of commercially processed and of dried but uncooked macadamia nuts were secured for chemical analyses and vitamin assays. The average composition of two lots of unsalted roasted nuts was found to be (in percentages): Moisture, 1.3; protein, 9.3; fat, 78.2; crude fiber, 1.8; carbohydrate, 8.0; total ash, 1.39; calcium, 0.053; phosphorus, 0.240; and iron, 0.0020. One hundred grams of nuts yield 773 calories, or 100 calories for 13 grams (6 to 7 nuts).

Biological tests did not reveal the presence of vitamin A in macadamia nuts. Peanuts and some other nuts are reported to contain little or none of this vitamin. Uncooked macadamia nuts were found to contain 486 micrograms of thiamin (162 I.U. vitamin B_1) per 100 grams. Roasting (cooking in refined coconut oil at 275° F. for 12 to 15 minutes) destroyed about 16 percent of the vitamin B_1. However, the roasted macadamias contained 408 micrograms of thiamin (136 I.U. vitamin B_1) per 100 grams, a value higher than that reported for roasted peanuts which are considered an excellent source of vitamin B_1. *(Miller, Louis)*

Vitamin B Content of Yeast Grown on Molasses

The yeast prepared experimentally by the Hawaiian Sugar Planters' Association experiment station has been tested biologically for vitamin B_1. The dried product was found to contain 5,280 micrograms of thiamin (1,760 I. U. vitamin B_1) per 100 grams. This value exceeds those reported for dried baker's yeast and some brewers' yeasts, and compares favorably with those of many samples of brewers' yeasts high in vitamin B. *(Miller, Kimura)*

Vitamin Assays of Filipino Vegetables

A number of vegetables used chiefly by the Filipinos in Hawaii but also by other racial groups have been assayed for vitamins A and B_1 (thiamin) by biological methods, and for vitamin C (ascorbic acid) by the chemical method.

Values for vitamins A and B_1 were determined on vegetables that had been steamed for 10 to 15 minutes (20 minutes for squash and bitter melon). Vitamin C values were determined before and after steaming. The results are reported in table 13.

Table 13.—Vitamin values of Filipino foods (per 100 grams)

Common name	Filipino name	Vitamin A	Thiamin[1]	Ascorbic acid	
				Raw vegetables	Steamed vegetables
		I.U.	*Micrograms*	*Milligrams*	*Milligrams*
Bitter melon	Ampalaya				
Fruit		166	40		
Tender leafy tips		20,800	112	88	20
Cowpea	Sitao	4,000	150	20	14
Goa bean	Pallang	700	174	0.5 or less	0
Horseradish tree	Malungay				
Leaves and tender tips		35,000	227	134	36
Pods				172	126
Hyacinth bean	Parda	560	118	13	7
Jute	Saluyot	6,200	73	36	1
Malabar nightshade	Libato	13,000	115	166	86
Pigeonpea (green shelled)	Kardis	1,700	486	33	49
Purslane	Ngalug	3,500	42	21	12
Squash, yellow	Calabaza				
Fruit		33,750	140		
Flowers		1,700	......		
Tender leafy tips		2,700	162		
Swamp cabbage	Kangkong	10,600	80		
Sweetpotato tops	Camote	8,500	176	11	2
Tomato	Camatis			30	

[1] Three micrograms of thiamin equal 1 international unit of vitamin B_1.

The vegetables containing unusually large quantities of vitamin A are the leafy tips of the bitter melon and the horseradish tree (see fig. 16) and the fruit of yellow squash.

The green pigeonpea is outstanding for high proportions of thiamin and ascorbic acid, and because it was the only vegetable of the group to show an increase in ascorbic acid after steaming. Such increases, as a result of reduction of dehydroascorbic acid, have been reported by others for a few vegetables. The pigeonpea, commonly used as a stock feed in Hawaii, may be considered a valuable emergency food for humans. In addition to containing vitamins, it is relatively high in protein (7.4%) and is a good source of minerals.

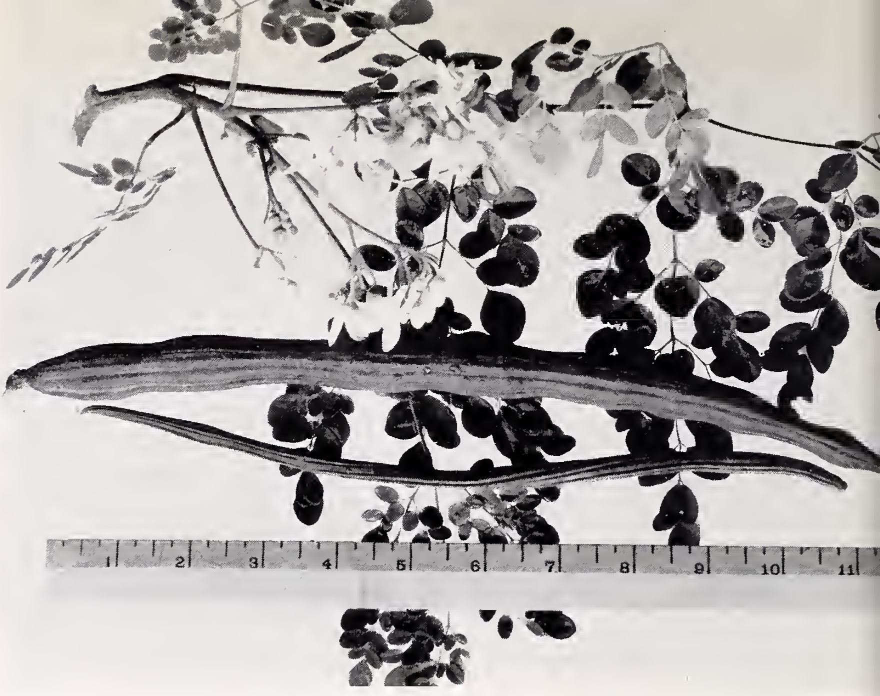


Figure 16.—Leaves, blossoms, and pods of the horseradish tree, shown to have a high nutritive value. The tree is growing in Filipino gardens throughout the Territory.

Large quantities of vitamin C were found in horseradish-tree pods and in Malabar nightshade.

A fish called monamon or dilis, which is eaten by the Filipinos in dried form or as a salted, fermented sauce, was found to contain little or no vitamin A or B_1.

Chemical analyses were made during the year on squash, hyacinth bean, cowpea, and tomato. A bulletin summarizing all of the vitamin assays and chemical analyses of Filipino foods is in preparation. *(Miller, Louis, Yanazawa)*

Analyses and Vitamin Assays of Hawaiian-Grown New Potatoes

In order to compare the nutritive value of locally-grown potatoes with values reported in the literature for potatoes grown on the mainland, analyses were made of samples from several localities on Oahu and of one sample of new potatoes from California. The results are summarized in table 14.

Preliminary experiments have shown cooked (boiled in the skin) Hawaiian-grown potatoes to contain 33 international units of vitamin B_1 per 100 grams. This value is considered high for potatoes.

Table 14.—Composition of Hawaiian-grown potatoes

Sample	Water	Protein	Total Ash	Calcium	Phosphorus	Total iron
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
No. 1	79.5	2.0	0.90	0.0048	0.038	0.00033
No. 2	80.0	2.0	.88	.0032	.039	.00035
No. 3, small	81.1	2.2	.89	.0055	.045	.00028
No. 4, large	80.8	2.1	.90	.0052	.043	.00027
California	80.1	1.6	.80	.0053	.052	.00033

Chemical tests of the vitamin C content also give unusually high values. The locally-grown potatoes contained, per 100 grams, the following quantities of ascorbic acid: Raw, 27 mg.; boiled in the skin, 22 mg.; baked, 29 mg. (calculated to fresh weight, 22 mg.). The single sample of raw California new potatoes was found to contain 13 mg. of ascorbic acid per 100 grams. *(Miller, Louis, Kimura)*

Family-Living Studies

In continuation of the studies of values of family living discussed in the annual reports for 1938 and 1939, records were kept during the past year, on food consumption of 36 families—1 Caucasian and 7 Hawaiian families at Lualualei, Oahu, and 28 Japanese families at Kona, Hawaii. As with families previously reported, the diets were found to be adequate in calories, phosphorus, and iron, high in protein, and low in calcium and vitamins, especially vitamin B_1.

Examination of 150 children in the 36 families indicated that 100 percent of the children of school age and 67 percent of the children of preschool age had dental defects. The Hawaiian children showed

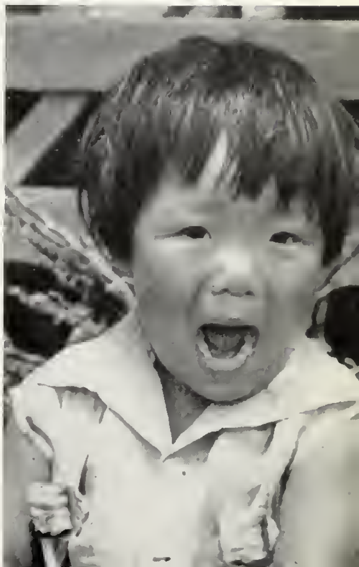


Figure 17.—Good physical and dental development in 3-year-old child, resulting from improved family diet following a diet study.

somewhat more resistance to tooth decay than the Japanese children. Correlations of dental defects, size, and nutritional status with adequacy of family diets will be calculated (see fig. 17).

The study of family food habits has been extended, in cooperation with the Territorial social security bureau, to families on relief in Honolulu. *(Potgieter, Kimura)*

Mechanical Tests of Vitamin-A Deficiencies

An instrument for testing night-blindness (nyctalopiometer) was constructed last year to determine slight shortages of vitamin A in the body. After various modifications of the method, 43 tests were made on 14 normal adults. The average recovery time of normal eyes, after a 5-minute exposure to light, was 1 minute, 39 seconds, with a range from 32 seconds to 4 minutes, 47 seconds. No subjects with abnormal recovery time (indicating a deficiency of vitamin A) have been found as yet.

It is hoped that the instrument may be developed for use in rural schools, to test children for slight deficiencies of vitamin A. *(Potgieter)*

Parasitology

Liver Fluke of Cattle

Drug Treatment of Fluky Cattle. Previous reports have shown that Distol is a safe and satisfactory drug for treating fluky cattle, but it is relatively expensive and obtainable only from Hungary. Kamala was also effective in destroying flukes, but treated animals often developed exhaustive diarrhea. Hexachloroethane in high concentration tended to induce colic.

During the past year it has been found that a combination of hexachloroethane and kamala extract is well tolerated by cattle and highly effective (see fig. 18). The drug was administered in capsules, each containing 10 grams of hexachloroethane plus 1.75 grams of kamala extract, at the rate of 1 capsule to 70 pounds of body weight. The total number of animals treated was 29; of these, 26 received half the dosage on 2 successive days. Three animals in very poor condition were treated over 3 days.

With 18 animals, where the fluke-egg counts before treatment were less than 35 per gram of feces, the drug reduced the egg count to zero. With the remaining 11 animals, where the egg counts ranged from 45 to over 300, the drug reduced the egg counts from 88 to 100 percent. Two animals, in poor condition, were dull and weak following the 2-day treatment. It would appear wise to treat such animals over a 3-day period, especially since the drug is apparently no less effective.

Estimation of Fluke Infection by Egg Counts. A method of estimating the number of flukes by determining the number of fluke eggs per gram of feces from a fluky cow has been developed over several years, and is described in detail in a paper to be published by the *American Journal of Veterinary Research.*[1] The method is of value since reduction in number of flukes can be determined, without destroying the animal so as to count the flukes in the liver.

As opportunities have arisen to make egg counts of fluky animals just prior to slaughter, data have been accumulated on the relationship between number of eggs per gram of feces and number of adult flukes in the livers.

[1] Alicata, Joseph E. *Studies on Control of the Liver Fluke of Cattle in the Hawaiian Islands.*

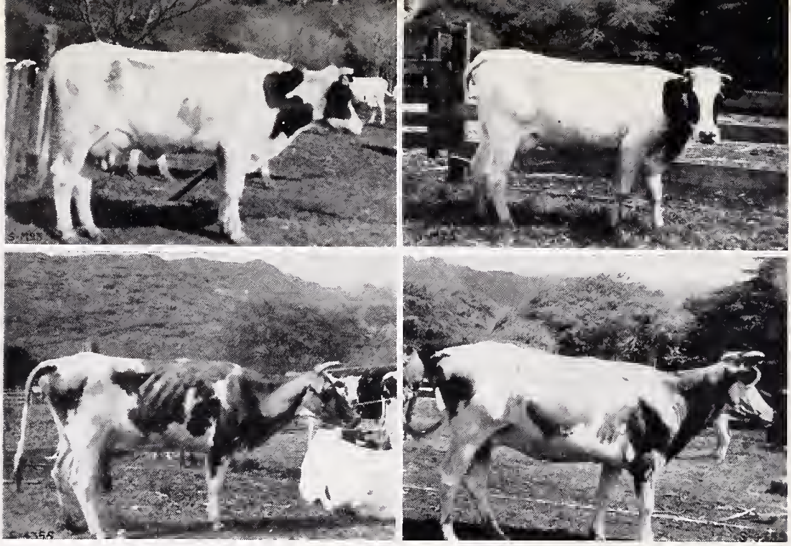


Figure 18.—Left, two fluky cows just prior to treatment with compound of hexachloroethane and kamala extract; right, same two cows, 4 months later.

The first consideration in the study was to determine the accuracy of sampling. Samples of feces were collected from each of 10 fluky cows on 10 successive days. The mean egg counts, standard deviations, and coefficients of variation are shown in table 15.

Table 15.—Accuracy of sampling of feces of fluky cattle over 10 successive days

Mean egg count per gram of feces	Standard deviation	Coefficient of variation
5.35	1.50	28
5.46	1.32	24
5.88	1.63	28
7.00	1.40	20
7.21	1.46	20
8.27	1.69	20
15.60	1.66	11
47.13	12.53	27
49.00	12.50	25
52.56	13.97	27

That significant differences occurred between animals in numbers of eggs passed each day cannot be questioned. Moreover, with one exception, the coefficients of variability are quite uniform, indicating that the count from a single sample from a cow passing a large number of eggs is no more variable than from a cow passing a small number. Thus the methods of sampling and of counting would appear to be satisfactory.

For ten cows records were kept of egg counts on 2 successive days prior to slaughter and numbers of adult flukes found in the livers after slaughter. It was found that the number of eggs per gram of feces ranged from 0.47 to 1.40 for every adult fluke found in the liver, the mean being 1.013 ± 0.108. The number of eggs per gram of feces is also clearly shown to be related to the number of adult flukes in the liver. Although the data are limited the regression coefficient was found to be $b = 0.755 \pm 0.062$.

Later records on 36 additional animals gave a mean egg count per adult fluke of 1.021 ± 0.35 when only one count was made for each animal. This figure compares favorably with the mean for the smaller number of animals. The regression coefficient $b = 0.90 \pm 0.059$ is also highly significant, indicating a straight line relationship between eggs per gram of feces and adult flukes found in the liver.

Biological Control of Snail Hosts. The possibility of controlling liver flukes in the Territory by destroying the intermediate snail host, *Fossaria ollula*, has been considered. A crayfish, *Astacus nigrescens,* introduced several years ago and now common in taro patches on windward Oahu, was observed under experimental conditions. Although this species proved to be an effective predator on snails, investigation into the habits of the crayfish showed that they are otherwise a pest, burrowing in the banks of taro patches and occasionally destroying taro corms.

Reports from Japan that two species of firefly *(Luciola lateralis* and *L. cruciata)* were helpful in controlling snail carriers of the human blood fluke turned attention toward these predators. The larvae of both species live in standing water and feed on fresh-water snails.

At the suggestion of this station, adults and eggs of these two Japanese fireflies and four other species of *Luciola* from the Philippines have been imported by the Board of Agriculture and Forestry. None of this material has as yet been released for experimental study, however. *(Alicata)*

Poultry Parasites

Relation of Nutrition to Tapeworm Infection. The annual report for 1938 discussed experiments which showed that protein supplements in poultry rations reduced ascarid infection. Last year a study on nutrition as a factor in reducing infection by the tapeworm

(Hymenolepis exigua) was reported. The first test indicated that plant-protein supplements (yeast, sesame meal, peanut meal, and soybean meal) were not so effective in reducing tapeworms as were animal-protein supplements (skim milk and fish meal).

Three additional tests have been conducted during the past year; results of all four are summarized in table 16.

Table 16.—Tapeworm infection in chicks fed supplemental plant and animal proteins

Supplement	Total digestible protein	Test	Number of birds	Average number of tapeworms per bird
Animal protein	16.04	a	25	14.12
		b	25	36.12
		c	25	41.36
		d	20	14.00
			95	*27.05*
Plant protein	16.59	a	25	65.60
		b	25	46.24
		c	25	45.44
		d	20	25.85
			95	*46.83*

The birds, each of which had been fed 100 infective tapeworm larvae at 3 weeks of age, were killed at 6 weeks of age. Birds on the plant-protein ration developed more tapeworms, on the average, than those on the animal-protein ration, but the results of the four tests are not fully consistent. *(Alicata)*

Plant Pathology

Yellow-Spot of Pineapple Virus on Tomato

Previous reports have shown that the virus of yellow spot of pineapple and that causing spotted wilt of tomato (see fig. 19) are identical. Further work with this virus has continued along the following lines: (1) Determination of the physical properties of the virus, (2) selection of resistant tomato varieties, and (3) prevention of infection by cultural methods.

The nature and physical properties of a virus furnish information as to its virulence and viability. The spotted-wilt virus is infective up to 6½ hours when held at laboratory temperatures in solution and is tolerant to 1 : 100,000 dilution but not to 1 : 200,000 dilution.

A number of tomato varieties said to be resistant to this virus have been obtained from Australia and are being tested in the field. The following seem to combine resistance and commercial desirability: Marglobe × Red Currant × Break O'Day, Earliana × Red Currant, Pilot, Early Beauty, and Indefatigable.

Tomatoes planted in one row, two rows, or three rows, between rows of full-grown sorghum (approximately 7 feet tall), were attacked by the virus as severely as tomato plants grown without sorghum windbreaks. The sorghum not only failed to hinder or prevent movement of windblown viruliferous thrips, but the presence of the sorghum caused a high percentage of plants to become diseased with aphid-transmitted viruses. *(Parris, Kikuta)*

Virus Disease of Papaya

The virus disease of papaya (see fig. 20), reported last year has not appeared in the field during the past year but has been kept alive in the greenhouse by artificial inoculation, using the previously

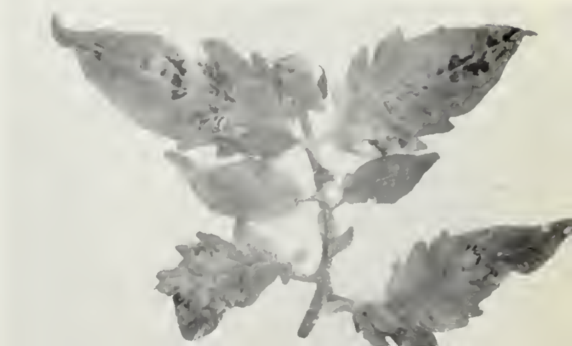


Figure 19.—Effect of yellow spot of pineapple on tomato leaf-zonate banding pattern of diseased tissue, accompanied by yellowing.

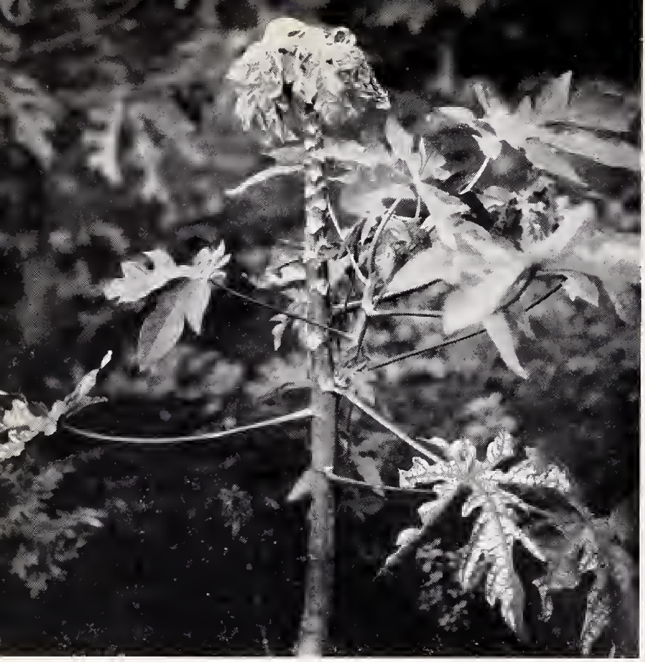


Figure 20.—Appearance of papaya plant diseased with virus; note that new shoot arising from middle of stem is healthy.

described mechanical abrasion method. Studies of the physical properties indicate that the virus is tolerant to at least 1 hour in solution and a 1:20 dilution. The disease has been transmitted from papaya to papaya by inarch grafting. *(Parris)*

Control of Anthracnose of Papaya

Anthracnose, caused by *Colletotrichum gloeosporioides,* is one of the most important economic diseases of papaya in that it affects the appearance and salability of the fruit. Results of a test initiated in November show that this disease may be controlled by spraying fruits at 14-day intervals with 4-4-50 bordeaux mixture, Cuprocide 54, or Cuprocide 54Y. Bordeaux-sprayed fruits, however, are russeted and rendered unsalable. The foliage is also affected. On the other hand, no russeting or foliage injury follows spraying with Cuprocide 54 or 54Y. Almost 100 percent of the fruits on unsprayed trees were without market value due to rotting by anthracnose.

Laboratory tests have also shown that bordeaux, Cuprocide 54, and Cuprocide 54Y are very toxic to the spores of *C. gloeosporioides* while Coposil and Copper Hydro 40 are much less so. With the first three fungicides from 94.5 percent to 99.7 percent of the spores failed to germinate, while with the last two less than 20 percent failed to germinate. *(Kikuta)*

Fruit and Stem Rot of Papaya

Phytophthora parasitica has been found in a single locality, causing appreciable destruction of fruits and killing the upper third of approximately 50 percent of the plants in a 4-acre planting. Diseased fruits dehisce prematurely and mummify (see fig. 21). Inoculations have shown that the fungus is a virulent wound parasite of stems and a weak wound parasite of roots. Trees of all ages are attacked. *(Parris)*

Leaf Spot Disease of Napier Grass

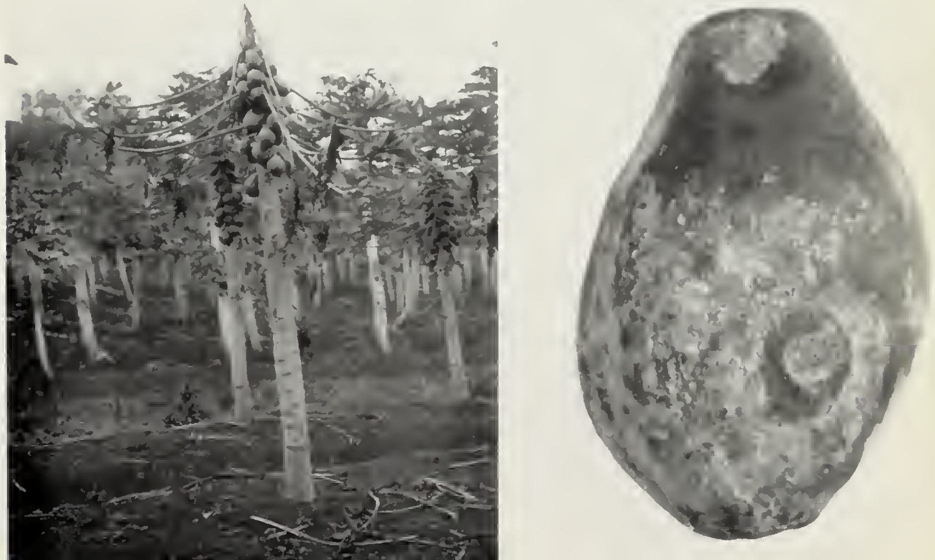
During the year Napier or elephant grass *(Pennisetum purpureum)* throughout the Territory was attacked by a species of *Helminthosporium* which killed leaves and stems. Severely attacked plantings are rendered almost worthless for forage. The disease has been found from sea level up to 2,500 feet and apparently is not influenced to any great degree by variations in rainfall.

Studies are in progress to determine the resistance of Merker grass and Napier-Merker crosses to the pathogene, and the possible relationship of the Napier organism to that causing eye-spot of sugarcane *(H. sacchari)*. *(Parris)*

Early Blight of Potato

Spray tests have been continued during the past year to determine the value of fungicides in the control of early blight of potatoes, caused by *Alternaria solani.* The most effective time for spraying has also been studied.

Figure 21.—Left, papaya plant severely diseased with Phytophthora parasitica. Right, diseased fruit, showing mildew (sporangia); ultimately fruits shrivel, turn brownish-black, and mummify.



Spray test 1. A 4-4-50 bordeaux spray was first applied to potato plots 30, 40, 50, and 60 days after planting, and thereafter in each plot at 10-day intervals. Cuprocide 54 and Cuprocide 54Y were first applied 50 days after planting and thereafter at 10-day intervals.

At the end of 80 days, the plots first sprayed with bordeaux 30 and 40 days after planting and with Cuprocide 54Y 50 days after planting outyielded the check plot. At the end of 90 days the same bordeaux treatments and the Cuprocide 54 showed slight but significant increases in yield.

Spray test 2. A test was conducted to determine whether differences in yield would result when bordeaux spray material of different ages was applied. Spraying began 40 days after planting.

There was no significant difference in yield between the unsprayed plants and plants sprayed with freshly-prepared, 2-day-old, or 4-day-old bordeaux.

Spray test 3. The 4-4-50 bordeaux spray, Cuprocide 54, and Cuprocide 54Y were each first applied at 40 days and at 50 days after planting.

The 4-4-50 bordeaux, applied first 40 days after planting gave a higher yield than the check plot in the 80-day and the 90-day harvest. The Cuprocide 54, first applied 40 days after planting gave a higher yield only in the 90-day harvest. Differences in yields in the other experimental plots were not significant.

Summary of Spray Tests. Results in general were disappointing. Increases in yield were so inconsistent that it is doubtful whether spraying potatoes for this disease repays the costs of the material and labor. This conclusion is drawn not only from the tests this past year but from similar tests over the preceding 2 years.

Even when early blight was abundant, unsprayed checks yielded as well or almost as well as sprayed plants, regardless of the fungicide used. These unexpected results can only be explained by assuming that: (a) The fungicides, as applied, were not effective in reducing infection; or (b) the fungicides reduced infection but exercised some deleterious effects on the potato plant.

It was apparent, however, that sprayed plants remained green longer and were more free from disease than the unsprayed plants. *(Parris, Kikuta)*

Potash Fertilization and Irrigation. Townsend[1] has reported that potatoes succumbed to the attack of *A. solani* 2 weeks earlier in plots without potash than in plots to which potash was applied. The effect on yield of doubling the potash increment in the standard potato fertilizer (12-30-6) was studied. The results obtained under the conditions of our test were entirely negative as there was no measurable difference between the two treatments in susceptibility to early blight.

Observations were also made on the effects of soil moisture on apparent resistance of potatoes to early blight.

Potatoes which were irrigated when deemed necessary did not receive adequate moisture as compared with plants irrigated regularly at weekly intervals and were less resistant to *A. solani* as evidenced by the fact that they were killed 2 weeks earlier. *(Parris, Kikuta)*

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[1] Townsend, G. R. *Early blight of potato.* Florida Agr. Expt. Sta. Ann. Rept. (1933-34): 86-112. 1935.

Table 17.—Reductions in yields of potatoes by *Heterodera marioni*

Fungicide applied	Replication	Severe galling of tubers	Yield per 100 plants
		Percent	*Pounds*
4-4-50 bordeaux	1	0	105
	2	30	88
	3	40	74
	4	56	66
	5	77	54
Cuprocide 54	1	0	102
	2	11	108
	3	37	94
	4	64	81
	5	71	59
Cuprocide 54Y	1	0	113
	2	34	86
	3	42	84
	4	50	73
	5	74	75
Check	1	2	112
	2	17	90
	3	19	93
	4	49	66
	5	83	52

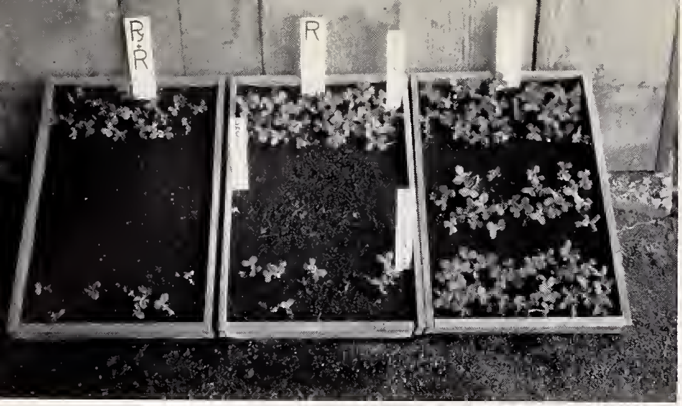

Figure 22.—A typical damping-off control test with the garden pea: Soil in flat on left infested with Pythium sp. plus Rhizoctonia sp.; flat in middle infested with Rhizoctonia; flat on right infested with Pythium. Seed treated with Semesan or with red copper oxide before planting or left untreated.

Nematodes on Potatoes

One of the spray tests presented an unusual opportunity to study the influence of nematodes upon yield. The root knot nematode *(H. marioni)* not only causes disfiguration, with subsequent low salability of potato tubers, but also reduces yields. The higher the percentage of tubers severely galled the lower the yield. The percentage of tubers showing severe galling was calculated by inspection of 200 mature tubers, collected at random from a 75-foot row of potatoes. Results are given in table 17 (preceding page).

Hovy[1] has reported that silver proteinate or silver nucleinate as it is also called, is of considerable value as a nematocide, applied at the rate of 0.3 gram per tomato plant. This material, at the above rate, mixed with potato fertilizer, was applied to infested soil before planting tubers. At harvesting, yields and percentage of tubers severely galled were obtained from treated and adjacent untreated plots. In two different trials no consistent increase in yield or reduction in percentage of tubers severely galled could be attributed to the presence of the silver salt. *(Parris, Kikuta)*

Damping-Off Studies

It is now concluded that *Pythium* and *Rhizoctonia* are the two genera of fungi largely responsible for damping-off in Hawaii with the latter the more cosmopolitan and destructive (see fig. 22). Semesan and cuprous oxide (red copper oxide) have been studied more fully with reference to their protective value and possible toxicity on different crop plants. The following are findings since publication of the last annual report:

Semesan. Use on cauliflower, kale, turnip, cucumber, squash, okra, alfalfa, and pea.

Semesan or cuprous oxide. Use on Swiss chard. *(Matsuura)*

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[1] Hovy, J. W. H. *Oligodynamic control of eelworm (Heterodera marioni).* Nature 144: 672. 1939.

Miscellaneous Plant Diseases

In table 18 is given a list of diseases noted in the Hawaiian Islands during the past year but not discussed in this report. *(Parris)*

Table 18.—Miscellaneous plant diseases noted in the Hawaiian Islands, July 1939 to June 1940

Disease		Host	
Causal agent	Common name	Scientific name	Common name
Alternaria sp.	Leaf spot	Gerbera jamesoni	Transvaal daisy
Bacterium sp.	do	Panax sp.	Panax
Bacterium sp. (woodsii?)	do	Dianthus caryophyllus	Carnation
Cercospora violae	do	Viola sp.	Violet
Colletotrichum sp. (phomoides?)	Fruit rot	Lycopersicon esculentum	Tomato
Colletotrichum sp. (nigrum?)	do	Capsicum frutescens	Pepper
Colletotrichum sp. (gloeosporioides?)	do	Annona cherimola	Cherimoya
Colletotrichum lagenarium	Fruit rot and leaf spot	Cucumis sativus	Cucumber
Fusarium sp. (conglutinans var. callistephi?)	Root rot	Callistephus chinensis	Aster
Fusarium sp. (lathyri?)	do	Lathyrus odoratus	Sweet pea
Fusarium sp. (lycopersici?)	Wilt	Lycopersicon esculentum	Tomato
Glomerella cingulata	Leaf spot	Lathyrus odoratus	Sweet pea
Heterodera marioni	Root-knot	Dahlia sp.	Dahlia
Leptosphaeria sp. (sacchari?)	Leaf spot	Pennisetum purpureum	Napier grass
Mosaic virus	Mosaic	Capsicum frutescens	Pepper
		Lathyrus odoratus	Sweet pea
Oidium caricae	Powdery mildew	Carica papaya	Papaya
Peronospora parasitica	Downy mildew	Brassica oleracea	Cabbage
Phyllosticta sp. (medicaginis?)	Leaf spot	Medicago sativa	Alfalfa
Phyllosticta sp. (sorghina?)	do	Pennisetum purpureum	Napier grass

Table 18.—(Continued).

Disease		Host	
Causal agent	Common name	Scientific name	Common name
Phytomonas campestre	Leaf spot	Brassica oleracea var. botrytis	Broccoli
Phytomonas phaseoli	do	Phaseolus lunatus	Lima bean
Piricularia sp. (grisea?)	do	Digitaria sanguinalis	Crab grass
Plasmodiophora brassicae	Club root	Brassica oleracea	Cabbage
Rhizoctonia solani	Bottom rot	Brassica pekinensis	Chinese cabbage
Sclerotium rolfsii	Root rot	Baleria sp.	
		Phaseolus vulgaris	Bean
		Solanum melongena	Eggplant

Plant Physiology

Factors Affecting Germination of Sugarcane

In the report of the station for 1939, effects of certain external and internal factors on cane germination were discussed. Further studies on germination of seed pieces in relation to length and bud position are summarized in table 19.

Table 19.—Summary of reaction of top seed pieces to length and bud position

Number of buds per piece	Number of pieces used	Position of terminal bud	Percentage of shoots		
			Above 50 cm.	20-50 cm.	Below 20 cm.
1	50	Up	100.0	0.0	0.0
	50	Down	94.0	4.0	2.0
	50	Side	98.0	.0	2.0
2	50	Up	56.0	8.0	36.0
	50	Down	74.0	20.0	6.0
	50	Side	76.0	24.0	.0
3	75	Up	54.6	24.6	20.8
	75	Down	38.6	18.8	42.6
	75	Side	66.7	21.3	12.0
4	100	Up	49.0	7.0	44.0
	100	Down	40.0	21.0	39.0
	100	Side	50.0	22.0	28.0
5	125	Up	42.4	14.0	44.0
	125	Down	37.9	16.5	45.6
	125	Side	49.6	24.8	25.6

The planting of one-bud or even two-bud seed pieces may not be practical, but by planting three-bud pieces with buds on the side, at least 66 percent of the shoots should be strong, if temperature and soil conditions are favorable. The influence of seed-piece length is extremely marked as the temperature drops.

Certain pre-planting treatments of seed pieces have been found beneficial under unfavorable planting conditions. Soaking in warm water (85° to 95° F.) for 24 to 48 hours gives substantially improved germination and vigor, but soaking in a warm 1-percent solution of calcium nitrate gives even greater assurance of an improved stand. *(Clements)*

Climatic and Physiologic Factors Affecting Production of Sugarcane

Observation of wide variations in yield of the same variety of sugarcane between two crop areas has led to an analysis of the factors affecting production in these two areas. A yield of 65 tons of cane at Kailua, Oahu, as compared with 134 tons at Waipio, Oahu, has been found to be directly related to climatic factors, particularly sunlight intensity. With adequate soil moisture in both areas and a slightly superior soil structure at Kailua, the difference in favor of the Waipio crop resulted from the greater atmospheric energy at the latter location together with a larger leaf area and a greater crop density.

In addition to complete weather records during the 22-month growth cycle, growth data were taken at intervals of approximately 1 month throughout the period. These data include records of terminal extension of selected pilot plants, the rate of leaf emergence, leaf area, and crop density. Plants collected at monthly intervals were completely divided in functional units and subjected to chemical analysis of various components, including simple sugars, sucrose, acid-hydrolyzable carbohydrates, total nitrogen, phosphorus, calcium, potassium, and moisture. As a result of correlations among these materials, the climatic records, and growth data, it has been possible to integrate climatic factors with physiological processes. Since the climate varies from year to year and from crop area to crop area, in order to apply fertilizer and irrigation water judiciously, it is necessary to use the plant or some part of it as an index of its own requirements.

The indices which are useful in determining the fitness of the plant to its specific environment are divided into the primary and secondary indices based on usefulness and importance. The primary index was found to be the total-sugar content of the sheaths associated with the young leaves. A perfect crop is one in which this index is uniformly maintained between 10 and 12 percent (dry weight) until the sixteenth month, after which it rises sharply to 20 percent or more.

Departures from this index are indicative of interfering factors which can be identified by reference to any one or more of the secondary indices. The moisture content of these same young sheaths shows a strong correlation with the plant as a whole and is used as the moisture index. The nitrogen, phosphorus, potassium, and calcium indices are based on analysis of the young leaf blades.

When the primary index is unusually high, the plant is producing less growth than normal. Factors causing this most commonly are low temperatures, low moisture, and low nitrogen, in that order. The minerals, phosphorus, potassium, and calcium, are very rarely the causes of a sudden decline in growth. When the primary index is unusually low, the plant is producing more growth than can be reconciled with quality. This is caused by high temperature, cloudiness, excessive moisture, or nitrogen. In all cases, the primary index essentially portrays the growth status of the plant and if properly maintained will yield the largest tonnage concomitant with quality possible under the particular climatic conditions. The advantage of using the index method over the empirical method is that a check can be kept on the crop while there is still time to correct any maladjustments. The empirical methods are much less helpful since results are not available until the final yield is harvested. Further, the results are of importance to the past crop but not to the present or future crops since the weather changes from year to year. *(Clements)*

Stimulation of Root Formation of Sugarcane With Ethyl Alcohol

The desirability of ensuring root formation for studies on germination of sugarcane led to the treatment of seed pieces with various growth-inducing substances, including indole butyric acid, water, ammonium phosphate, calcium nitrate, and ethyl alcohol.

A 5-percent solution of 95 percent ethyl alcohol proved to be the most effective treatment for stimulating root formation, especially at low temperature (69°-75° F.). Optimum time of treatment was between 24 and 48 hours. Less stimulation occurred in young seed pieces than in more mature planting material, suggesting that the ethyl alcohol serves as a readily available, high-energy food. *(Clements, Akamine)*

Movement of Organic Solutes in the Sausage Tree

Movements of organic solutes in the fruits of the sausage tree, *Kigelia africana*, as studied over a period of 3 months, tend to disprove the concept of a concentrated sugar solution (at least 10 percent)

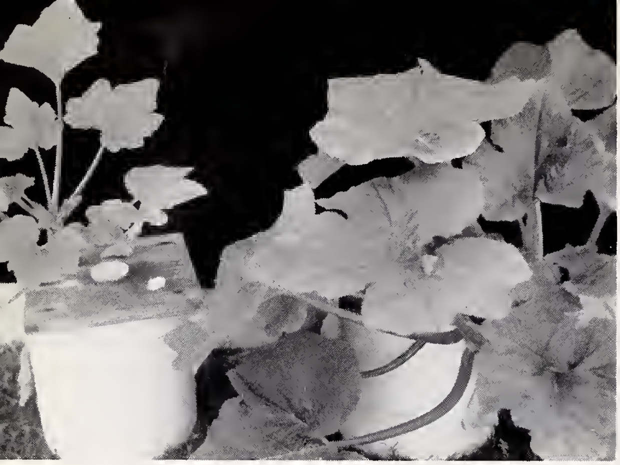

Figure 23.— Left, plant of Cucurbita pepo at low metabolic level; right, plant at high metabolic level. The quantity and composition of the exudate of this species at three metabolic levels were studied.

moving en masse through passive phloem tissues, the water, after depositing its sugar, then returning by way of the xylem tissues.

By monthly analysis of the phloem tissues of representative fruits, the rate of solution-movement necessary to transport the sugar present in the fruits was established. An attempt was then made to explain this movement on the basis of the mass-flow hypothesis. The hypothesis was found to be inadequate in the following particulars:

1. Although a passive sieve-tube cytoplasm is necessary to the concept, the greatest movement of materials into the fruits was observed during the first 5 weeks of development, when the protoplasm is most active.

2. Although the strength of the sugar solution has been assumed to be at least 10 percent, the phloem tissue of these fruits was found to have a reducing-sugar level of only 0.62 percent and a total-sugar level of 1.75 percent.

3. No evidence could be obtained to substantiate the return of water from the fruit through xylem tissue.

4. On the basis of sugar content of the phloem tissue, the necessary speed of solution-movement would be many times the capacity of the xylem tissues.

As a result of these findings, the conclusion was drawn that the observed movement of sugar into the fruits of the sausage tree must be described as a function of the living protoplasm of the sieve tube. *(Clements)*

Translocation of Organic Materials in Cucurbita pepo

In a study of the significance of phloem exudate in reference to translocation of organic materials, the quantity and composition of the exudate of the cucurbit were determined at several times during the day from plants at three metabolic levels (see fig. 23): (1) young plants, growing very rapidly, (2) plants which were fruiting but which had an adequate supply of nitrogen, and (3) those of the same age as (2) but with a low metabolic level because nitrates had been withheld from the culture solution. The quantity of exudate bore no relationship to the quantity of translocation but was specifically shown to be correlated with the osmotic relations of the tissues at the time of cutting.

More than one-third of the dry matter of the exudate is protein, pointing to a dense, active cytoplasm of the sieve tubes from which the exudate is shown largely to arise. Sugars represent less than one percent of the fresh weight. The composition of the exudate shows no relation to the composition of the adjacent tissues. In plants with a high metabolic rate, the sugars of the tissues are very low while those of the exudate are relatively high. In plants with a low metabolic rate the sugar content of the tissues is very high while that of the exudate is low. The intermediate plants are intermediate in their composition. The data on quantities of exudates and their composition indicate that the mass flow hypothesis is untenable, and that translocation intensity apparently is correlated with the metabolic level of the plant. *(Cooil)*

Arsenic Toxicology

Tomatoes grown in water cultures, in the presence of sodium arsenite, accumulated less arsenic in the fruits than in the leaves and stems. The total yield (fruits, stems, and leaves) was markedly and progressively reduced by arsenic, even the most dilute concentration—½ part per million—reducing the yield by 20 percent.

Arsenic toxicity in the tomato was partially dependent on phosphate availability (see fig. 24). As the phosphorus level was increased, within certain limits, the plant survived greater concentrations and absorbed less arsenic.

In repeated croppings, less arsenic was accumulated in the tops of each plant, but the roots continued to absorb large quantities. *(Heggeness)*

Germination of Grass Seeds

Continued experimentation has established methods of breaking dormancy and increasing germination of seeds of four species of grass.

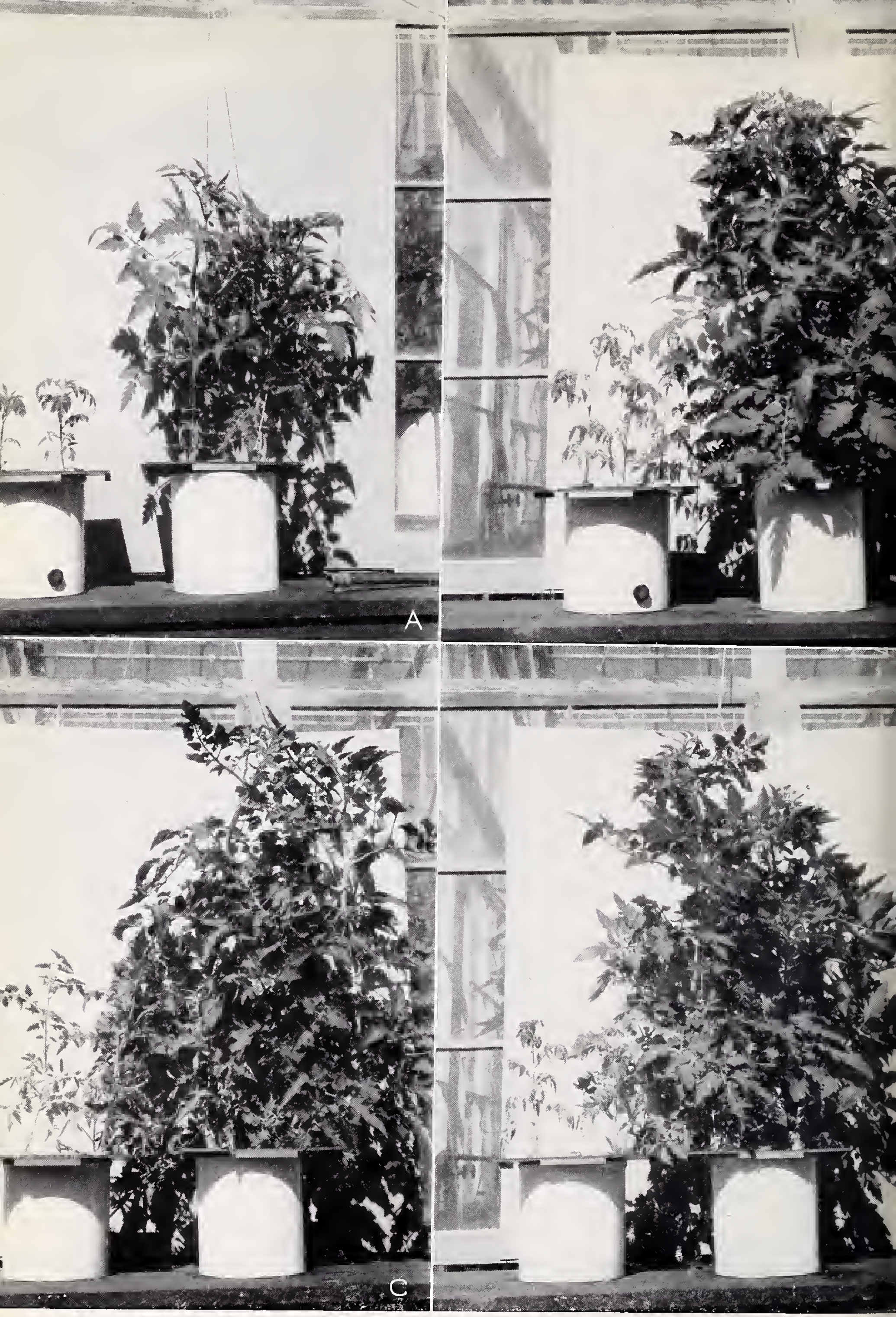

Figure 24.—Effects of phosphate at various levels on toxicity of sodium arsenite to tomato plants in water culture. All cultures at left are the same as those on the right except that 5 parts per million of As_2O_3 *were added as sodium arsenite. Cultures at A have one-half the normal amount of phosphate; cultures at B have the normal amount; C, twice normal; D, three times normal.*

Paspalum notatum, *Panicum prolutum*, and *Pennisetum ciliare* increased in germination after being soaked in concentrated sulfuric acid for varying periods. The optimum period for *Paspalum notatum* was between 30 and 35 minutes; for *Pennisetum ciliare*, only 10 to 15 minutes. Records taken 28 days after planting indicate that maximum germinations of 60 to 80 percent can be secured by treatment, whereas untreated seeds show less than 5 percent germination.

Panicum prolutum, in one test, germinated around 40 percent after soaking in tap water for 72 hours. Another lot of seed, however, apparently with harder seed coats, required scarification with concentrated sulfuric acid for 20 minutes before equivalent germination was secured.

Seed of *Pennisetum setosum* were soaked for 24 hours in solutions of various chemicals which are known to furnish nitrogen, promote growth, or regulate respiration. A 1-percent solution of ammonium sulfocyanide, which is both nitrogen carrier and a respiratory stimulant, improved germination from around 50 percent to over 90 percent. Potassium nitrate and vitamin C solutions also increased germination. Repeated experiments with ammonium sulfocyanide, however, indicate that the condition and temperature of the soil may determine whether the seed benefit from treatment. *(Akamine)*

Poultry Husbandry

Fowl-Pox Vaccination of Day-Old Chicks

Day-old chicks were divided at random into 3 groups of approximately 100 chicks each. Chicks in group 1 were not vaccinated but were held as a check in a mosquito-proof room. Chicks in group 2 were vaccinated in the wing by the stick method as they came from the incubator, and were placed at once in a screened brooder. Chicks in group 3 were vaccinated on the thigh by plucking the down from a small area and applying the vaccine with a stiff camel's hair brush.

At 6 weeks the chicks from all lots were transferred to two wire-floored, unscreened houses. Older chicks infected with fowl pox were placed in the pens with the experimental chicks. After 10 days a careful inspection was made of each chick.

Although the chicks showing positive reactions were considerably fewer in the vaccinated lots, the mortality was much higher than in the check lot.

The high losses among the vaccinated groups were attributed to severe reactions from use of too coarse a needle and exposure of too much surface on the leg.

A second test was initiated in which a finer needle was used in vaccinating in the wing, and no down was plucked from the thighs (see fig. 25). The vaccine was applied to the undisturbed skin surface.

Again mortality was excessive in group 2, in spite of the use of a smaller needle. The large number of positive reactions in group 3

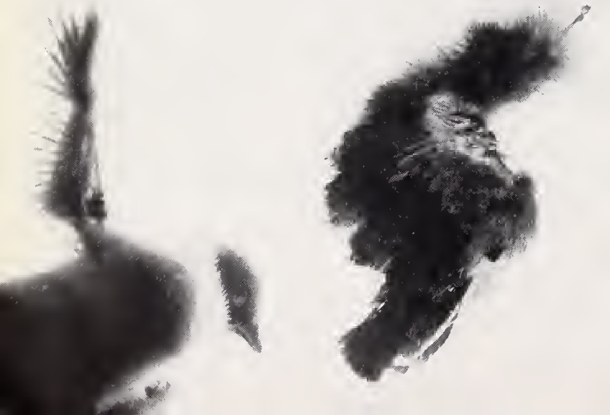

Figure 25.—Vaccination scabs on webs of chicks' wings: Left, mild reaction due to use of fine needle; right, severe reaction.

indicated that the application of vaccine to the thigh with no removal of down is ineffectual. *(Weaver)*

Breeding for High Egg Production

In the spring of 1939, 10 pens of Leghorn breeders, 3 of Barred Plymouth Rocks, and 2 of Rhode Island Reds were mated, and the female progeny were placed in the laying pens in the fall of 1939. Trapnest records of egg production have been kept. All birds removed from the pens by culling or death are considered as cases of mortality. This procedure obscures somewhat differences in production and disease resistance between matings but gives excellent material from which to select for new matings. *(Weaver)*

Home-Made Egg Cooler

A series of four tests were run in which an insulated egg-cooling cabinet was compared with an open room as a place for holding eggs. The cabinet was constructed with inside dimensions of 28 by 31 by 41 inches. Three sides and the top were of double-wall construction with 4 inches of sawdust as insulating material. The fourth side was closed by a double curtain of burlap, dipping into a tank of water at the top. A float valve held the water at a constant level, within one-half inch of the upper edge of the tank. The cabinet was divided into sections by a woven-wire partition. Eggs were candled and graded before and after being placed in the cooler.

Temperature inside the cooler averaged 5 degrees lower than outside temperature. Relative humidity averaged 15 percent higher inside than outside. Under these conditions eggs which were held as long as 7 days still graded 80 to 90 percent fancies and extras in the cooler, but less than 50 percent outside. Held longer than 7 days, the eggs lost quality rapidly even in the cooler.

It was not possible to get the temperature down to the desired 60° F. at the University farm. In localities where the air is normally drier and where lower average temperatures prevail, the cooler may be more effective. *(Weaver, Blake[1])*

Incubation of Muscovy Ducks

Since Muscovy duck eggs do not hatch well in incubators, a test was conducted to determine whether the difficulty could be overcome.

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[1] Senior student.

Two small electrically-heated and controlled incubators were operated at 100° and 102° F. Humidity was maintained by shallow pans of water in the bottom of each machine in which 37 Muscovy duck eggs were placed. Thirty additional eggs were divided among three broody hens. Eggs were turned 4 times daily. Moisture loss was determined by periodic weighing of all eggs individually.

The operating temperature of 100° gave a hatch of 58 percent while 102° gave only 25 percent. Hatch by broody hens was 80 percent.

A second test was run in which the temperature was held at 100° in both machines but moisture varied. Another variation was to move eggs from the incubators to the hens and vice versa at the end of 2 weeks.

Loss of moisture from the eggs in incubator No. 2 was restricted in two ways: (a) Surface area of the moisture pans was slightly greater, and (b) larger eggs were used (less evaporating surface in relation to contents of eggs). Twenty eggs were placed under two broody hens. After 2 weeks of incubation 10 eggs were taken from one hen, and 5 of them placed in each incubator.

In this test the hens produced a 68-percent hatch; the restricted-moisture incubator, 54 percent; and the normal-moisture incubator, only 28 percent. All of the eggs transferred from the hen to the incubators at the end of 2 weeks hatched, while only 5 of the 10 eggs transferred from the incubators to the hen hatched. Apparently the first 2 weeks are most critical in incubation, a fact which can be used to advantage by duck raisers. *(Weaver, Tsubota[1])*

Rations for Growing Chicks

Pineapple sirup. Five lots of 33 chicks each were employed in an experiment to determine the value of pineapple sirup as a substitute for corn meal in chick rations. One lot on a standard ration served as a check, one lot received 7.5 percent cane molasses, and three lots were fed pineapple sirup at 7.5-, 10-, and 15-percent levels.

All of the lots receiving pineapple sirup made better gains than did the chicks receiving cane molasses. Of the experimental lots, the 10-percent pineapple sirup was superior. However, the chicks on the standard ration made the best gains of any lot in the test, and their feed costs were lowest. *(Weaver, Kong[1])*

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[1] Senior student.

All-island ration. An attempt was again made to develop a chick ration exclusively of local products, chiefly pineapple bran, algaroba bean meal, and molasses yeast. Results were so poor that the test was discontinued. *(Weaver)*

Rations for Laying Hens

Pineapple bran. Four pens of 15 Leghorn hens each were placed on test to determine the value of 4 pounds of pineapple bran and 1 pound of soybean meal as a substitute for 5 pounds of ground oats in rations for laying hens. One lot served as a check while the other three lots received rations containing pineapple bran at 10-, 15-, and 20-percent levels.

Egg production and hatchability were highest for the 15-percent pineapple bran group.

Yeast-fermented mash. Work reported in 1939 indicated that pullets confined in a battery produced more eggs on a yeast-fermented mash than on the fresh mash moistened with water. This experiment has been continued for a second year with 40 of the 60 original pullets in their second year of lay and 20 additional birds in their first year. Records were kept of egg production, changes in body weight, and mortality.

Differences in egg production during this past year were not so great in favor of the yeast-fed group as in the previous year. Mortality was excessive among birds in their second year of lay on both rations.

Soil Physics

Heat-of-Wetting Studies

Apparatus and Technique. Improvements in methods for determining the heat evolved when soils are saturated have included the use of a room of fairly constant temperature, the determination of the water equivalent of the system by electrometric methods both before and after each test, and the introduction of conventional radiation corrections based upon air and calorimeter temperatures at frequent intervals for a period that may extend for more than 2 hours.

Sealed glass bombs continue to serve as sample holders, prior to the time of wetting. When oven-dried soils are involved, the dry soil is sifted into the blown bulb through a narrow neck. The loaded bombs are then heated to 105° C. for 48 hours. The seal is made by means of a hot flame while the bombs are hot from the oven. If the determination is to be made on samples containing some moisture, the bomb is sealed as soon as the prepared soil is introduced.

Some difficulty was experienced when dry soils were used because such bombs often float. To avoid this difficulty soils with low volume weights were sealed into relatively thick-walled bombs or into bombs carrying a drop of glass for a counterpoise. Samples contained from 15 to 20 grams of material.

When every precaution is taken, replicate tests may be expected to check within 0.2 calory per gram of oven-dried material. Discrepancies greater than this may be attributed to differences in the samples.

A constant-temperature room and radiation correction are essential if extreme precision is required.

Effect of Non-Uniform Moisture Distribution. Many Hawaiian soils are characterized by a stable, granular structure; thus it is difficult if not impossible to bring such soils to a predetermined moisture content with any assurance that the moisture is uniformly distributed over the ultimate surfaces. Lack of uniformity of distribution results in greater heats of wetting than would be noted if uniform distribution had been secured.

Samples of oven-dried soil were exposed in desiccators to the water vapor over sulphuric acids of varying concentrations until apparent equilibrium was attained. Other oven-dried samples were brought to similar moisture contents by exposure to a blast of saturated air in a rotating box. The heats of wetting of the several samples were determined with the results shown in table 20.

Table 20.—Comparisons of heats of wetting of soil samples brought to similar moisture contents by desiccation and by exposure to air blasts

Soil moisture (Oven-dried basis)	Heats of wetting per gram	
	Desiccator samples	Air blast samples
Percent	*Calories*	*Calories*
1.87	2.66	3.25
2.37	2.14	2.35
4.16	1.09	1.40

It is apparent that the moisture content of a soil as determined by conventional means is not the only indication of the soil's capacity to generate heat upon saturation.

With oven-dried soils, increasing the temperature of the oven during drying increases the heat of wetting. Differences in the temperature of drying, within the accuracy of most drying ovens, are significant.

Moisture percentages between 3 and 6 appear to be optimum if reproducible heat of wetting results are desired.

Original Soil Moisture Content. Seventy-eight soil bombs were prepared to test the relationship between the heat of wetting and the original soil moisture content. The moisture contents were so adjusted by preliminary treatment that statistical interpretation of the results was possible. Although an exponential relationship was suggested when the heats of wetting were plotted against moisture contents, the conventional logarithmic plotting suggested two intersecting lines in place of one. Other workers have similarly noted intersecting straight lines when the relative humidities associated with varying moisture contents were plotted against moisture contents.

Effect of Replaceable Bases. Six soils representing widely different conditions of local weathering were treated with dilute calcium solutions until a pH of about 7.0 was secured. Heats of wetting were then determined on the oven-dried material. Although the heats of wetting with the calcium-treated soils were always slightly greater than similar results from untreated soils, the differences were not great and perhaps not significant. It is not known whether this result is due to inability to replace other cations in the six soils with calcium by this means, or to a high original calcium content. The same soils are being saturated with hydrogen by electrodialysis. The results from this series will contribute to our knowledge of the significance of base hydration upon the measurable heat of wetting.

Granule-Stability in Hawaiian Soils. It has been suggested that many of the physical properties of Hawaiian soils are due to the water-stability of soil granules. This hypothesis is being tested by scouring dispersed soils in an electriator operating under a wide range of velocities. *(Wadsworth, Inn)*

Branch Stations

Haleakala Branch Station

The largest area at this station and at the Olinda Substation is devoted to work on grasses and legumes, including grass nurseries (see fig. 26), grazing cafeterias, pastures, and cultural and fertilizer trials. In addition, 5 acres are planted to horticultural crops, chiefly macadamia and litchi trees and berries.

Concentrated efforts were made during the year to systematize field notes on vigor, yield, recovery, and variations in the grass gardens. In pasture grazing trials, notes were taken on persistence, aggressiveness, recovery, palatability, and carrying capacity.

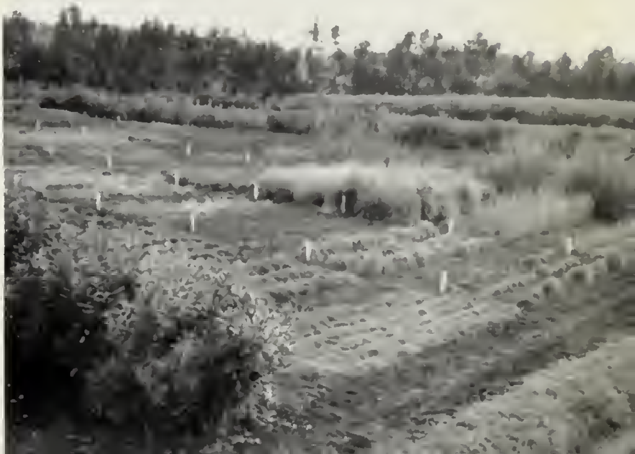
Studies on clovers at this location offer promise, and various nurse crops and fertilizer combinations are under observation.

Plantings of corn have been made at 6-week intervals to observe yields from various planting dates for areas of similar elevations and climatic conditions.

Periodic pruning, training, and cultural care have been given 183 macadamia trees in a varietal test planting. Adaptability to this elevation of 59 litchi trees is also being studied.

Youngberries appear to be more vigorous than boysenberries, but yields of both varieties were disappointing. To date none of the 18 varieties of strawberries under test has shown marked adaptability.

Figure 26.—General view of grass garden at Haleakala branch station.



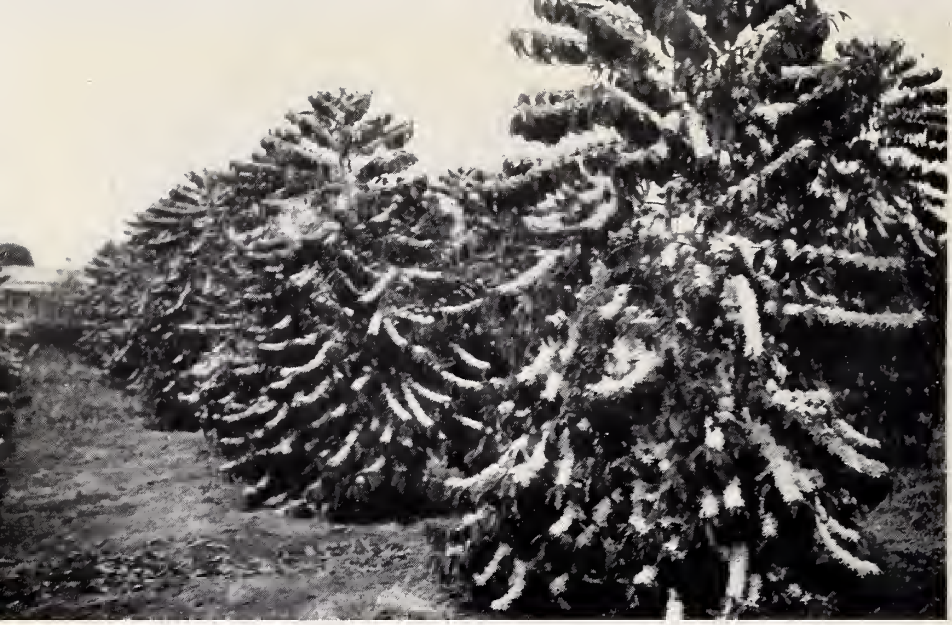


Figure 27.—Young coffee orchard in bloom at Kona branch station; this heavy bloom resulted in excessively high yields of cherries followed by severe dieback of the trees.

During the year new cattle weighing scales, holding pens, and feeding pens were constructed. Plant propagation sheds were moved to a more favorable location, and a new cold frame was built. *(Murphy)*

Kona Branch Station

Coffee investigations (see fig. 27) included monthly measurements of circumferences and lateral and terminal growth of six young coffee trees, and the collection of monthly leaf samples from station trees and from cooperative fertilizer test trees. Several farmers' meetings were held in cooperation with the Agricultural Extension Service, at which fertilizer demonstrations were given. A one-day coffee institute was attended by some three hundred coffee farmers. Demonstrations and discussions included results of investigations on fertilization, pruning, and weed control.

A macadamia variety orchard was planted at the station as a source of graftwood, and two cooperative seedling plantings of 400 trees were set out for future selection work. During the year, 1,365 grafted trees of 40 selected varieties were grown, packed, and set out in macadamia test orchards on Kauai, Maui, and Oahu. Macadamia grafts numbered 1,474, and 2,000 rough-shell and 1,500 smooth-shell seedlings were planted in nursery rows for rootstocks.

The object of avocado investigations is to select good varieties which will fruit when present trees are not bearing, thus carrying avocado production through the entire year. Toward this end, 60 grafts were made of 4 selected varieties. In addition, wood for 600 grafts was distributed among farmers and home owners.

Experiments with citrus, mangoes, strawberries, and taro are receiving attention. Grafts of 5 selected varieties will soon be made on 300 mango stocks, for field planting next year.

In addition to fruit and nut investigations, assistance has been given on the Kapapala cattle feeding test.

Seven acres of new land have been cleared and planted, and a watershed set up with a 15,000-gallon water tank for irrigation purposes. *(Pahau)*

Poamoho Farm

Experimental work during the year consisted of replanting 7 acres of papaya and 4 acres of mango trees, developing a 1-acre nursery, and planting 12 acres of potatoes, a small Guinea grass plot, and a sorghum test. Experiments begun last year with asparagus, macadamia trees, and a grass garden were continued.

In cooperation with the Soil Conservation Service, the front section of Poamoho farm was terraced to prevent extensive erosion. Where the slope was moderate, the Alabama (Nichols) type of terrace was constructed, with a broad, shallow channel and a moderate mound on the lower side. Terrace outlet channels were made at the ends of the terraces.

A tractor and equipment were purchased during the year. *(McDougal)*

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No.

84. Whitney, L. D., Bowers, F. A. I., and Takahashi, M. *Taro Varieties in Hawaii.* December 1939, 86 pages.
85. Henke, L. A., Work, S. H., and Burt, A. W. *Beef Cattle Feeding Trials in Hawaii.* June 1940, 37 pages.

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14. Jones, Winston W., Holzman, J. J., and Galloway, A. G. *The Effect of High-Temperature Sterilization on the Solo Papaya.* September 1939, 8 pages.
15. Alicata, J. E., Swanson, Leonard E., and Goo, G. W. H. *Methods of Controlling the Liver Fluke of Cattle in Hawaii.* June 1940, 23 pages.
16. Jones, Winston W. *Vapor-Heat Treatment for Fruits and Vegetables Grown in Hawaii.* June 1940, 8 pages.

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No.

39. Dean, L. A. *Relationships Between Rainfall and Coffee Yields in the Kona District, Hawaii.* Jour. Agr. Res. 59(3): 217-222, illus. August 1939.
40. Beaumont, J. H. *An Analysis of Growth and Yield Relationships of Coffeetrees in the Kona District, Hawaii.* Jour. Agr. Res. 59(3): 223-235, illus. August 1939.
41. Miller, Carey D., and Robbins, Ruth C. *Chemical Analysis and Vitamin Assays of Opihi, the Hawaiian Limpet.* Philippine Jour. Sci. 71(2): 141-163, illus. February 1940.
43. Hartung, M. E., and Storey, W. B. *The Development of the Fruit of Macadamia ternifolia.* Jour. Agr. Res. 59(4): 397-406, illus. September 1939.
45. Jones, Winston W. *A Study of Developmental Changes in the Macadamia.* Plant Physiology 14: 755-768, illus. October 1939.
46. Henke, L. A., and Goo, G. W. H. *Comparative Value of Napier and Sudan Grass When Used as Soiling Crops for*

Dairy Cows. Jour. Dairy Sci. 22(12): 1007-1010. December 1939.

47. Alicata, Joseph E. *Diet and Its Relation to Parasitic Infection, with Special Reference to Poultry.* Bernice P. Bishop Mus. Spec. Pub. 34: 14, 1939.

48. Parris, G. K. *A New Disease of Papaya.* Bernice P. Bishop Mus. Spec. Pub. 34: 25, 1939.

49. Hamre, Christopher J. *The Capillary Hematocrit Method of Determining Blood Cell Volume.* Jour. Lab. and Clin. Med. 25(5): 547-551. February 1940.

50. Parris, G. K. *Mechanical Transmission of Yellow-Spot Virus: Evidence for Identity with Spotted-Wilt Virus.* Phytopathology 30: 299-312, illus. April 1940.

51. Ballard, Stanley S., and Dean, L. A. *The Use of Radioactive Phosphorus in Soil Studies.* Jour. Appl. Phys. 11(5): 366-370, illus. 1940.

53. Work, S. H., and Henke, L. A. *The Value of Urea as a Protein Supplement for Dairy Heifers.* Amer. Soc. Anim. Prod. Proc. (1939): 404-406. 1940.

54. Jones, Winston W. *A Convenient Method for Measuring Relative Humidity in a Gas Train System for Measurement of Respiration.* Science 91 (2356): 202, illus. February 1940.

55. Alicata, J. E. *The Life Cycle of Postharmostomum gallinum, the Caecal Fluke of Poultry.* Jour. Parasitol. 26 (2): 135-143, illus. April 1940.

56. Jones, Winston W. *The Influence of Relative Humidity on the Thermal Death Point of Papaya as Indicated by Respiratory Curves.* Amer. Soc. Hort. Sci. Proc. (1939) 37: 119-124, illus. 1940.

59. Parris, G. K. *A Check List of Fungi, Bacteria, Nematodes and Viruses Occurring in Hawaii, and Their Hosts.* U.S.D.A., B.P.I., Plant. Dis. Rptr. Sup. 121, 91 pp. March 1940.

60. Wilsie, Carroll P., Akamine, E. K., and Takahashi, M. *Frequency of Cutting of Napier Grass.* Amer. Soc. Agron. Jour. 32(4): 266-273, illus. April 1940.

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(Pierson)

FISCAL STATEMENT—1939-1940

	Federal Acts				Territorial		Grant for soil research	Total
	Hatch	Adams	Purnell	Bankhead-Jones	Bankhead-Jones Offset	Special		
RECEIPTS								
Received from the Treasury of the United States	$15,000.00	$15,000.00	$30,000.00	$9,186.40				$ 69,186.40
Receipts from Territorial funds					$9,186.40	$73,497.90		82,684.30
Receipts from sales						21,238.25		21,238.25
Receipts from other sources							$1,200.00	1,200.00
Total receipts	$15,000.00	$15,000.00	$30,000.00	$9,186.40	$9,186.40	$94,736.15	$1,200.00	$174,308.95
DISBURSEMENTS								
Personal services	$13,915.73	$13,837.25	$29,468.56	$8,892.08	$6,186.71	$59,111.91	$1,000.00	$132,412.24
Supplies and materials	323 29	889.11	447.39	294.32	168.91	16,656.16	159.99	18,939.17
Communication service						952.21		952.21
Travel expenses			41.40			809.52		850.92
Transportation of things		3.75				217.20		220.95
Printing and publications	746.44				1,257.88	124.64		2,128.96
Heat, light, water and power						3,226.75		3,226.75
Contingent expenses	14.54	5.50				6,279.49		6,299.53
Equipment		264.39	42.65		1,572.90	4,267.43		6,147.37
Structures and non-structural improvements						3,090.84		3,090.84
Balance unexpended, June 30, 1940							40.01	40.01
Total disbursements	$15,000.00	$15,000.00	$30,000.00	$9,186.40	$9,186.40	$94,736.15	$1,200.00	$174,308.95